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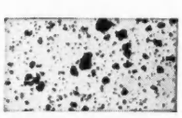
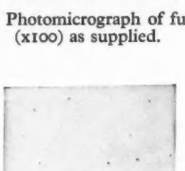
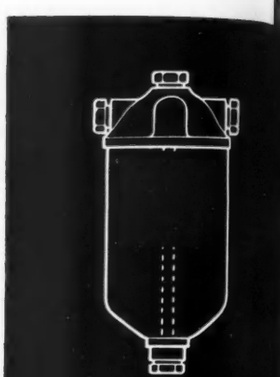


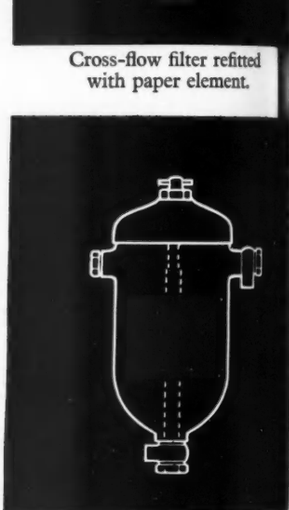
(a) Photomicrograph of fuel (x100) as supplied.



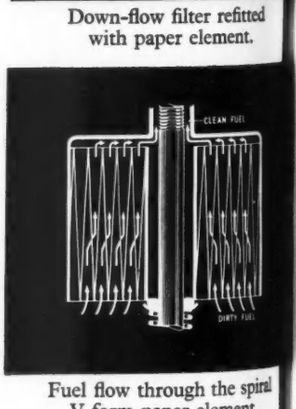
(b) Photomicrograph of fuel (x100) after filtering with the new element.



Cross-flow filter refitted with paper element.



Down-flow filter refitted with paper element.



Fuel flow through the spiral V-form paper element.

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ENGINEERING

An Illustrated Weekly Journal

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HOME THOUGHTS FOR ABROAD

FOR the past ten days the world has looked at Britain with dismay. The Government's military action in Egypt has been deplored wherever we were regarded, in some sense, as moral leaders in power politics. In those countries where we were regarded as decadent fools our action was welcomed as a timely smoke-screen for their own resolute plans. Has the British lion suddenly become so touchy that he leaps up snarling at the slightest sound of an intruder? For many years he has been slow to anger; was that just a passing phase?

The Government's action has divided the nation. Some responsible newspapers have called for the resignation of the Prime Minister. There have been rowdy demonstrations, and even those who are inclined to support the Government regret deeply the damage which has been done to our international reputation. Public feeling has run very high. War, it is felt, should be avoided at all costs—that is the view of the mass of people; and among those who see a little farther than most, their country stands for the defence of minorities against ruthless dictators, an attempt to apply moral or religious principles to the conduct of states. The events of last week seemed to shatter all these beliefs.

Do not hold Sir Anthony Eden wholly responsible for this swift change in our affairs. Apart from one minister who has resigned, all members of the Government are responsible. Why, then, did they back this move which has alienated many of the electors, presented the Labour Party with a golden and unexpected opportunity, and embarrassed many of our friends overseas? "In the depths of our conviction we decided that here was the beginning of a forest fire of immense danger to peace. We decided that we must act and act quickly." In his broadcast last Saturday the Prime Minister summed up the reasons in these words. He recalled Colonel Nasser's repeated threats to exterminate Israel, and he reminded his countrymen that the mood of "peace at any price" had cost us dearly in the 1930's.

In pre-atom bomb times international relations were dominated by the major industrial powers. Now, however, it is an ironical fact that the atom bomb—industry's most diabolical invention—has given small states the chance to play ducks and drakes with the major powers. The fear of a world war is so real and so well-founded that Britain, the United States and the U.S.S.R. have generally avoided any action which might precipitate an outbreak. Into this delicately balanced situation a small country, with meagre economic resources and no inherent right to set the pace, can step like a precocious child. And like a precocious child Egypt demands privileges and freedom of action which she is too young, politically, economically and industrially, to exercise. Colonel Nasser aims to control the most vital and significant area of the world—the Middle East. He must not be allowed to achieve his ambition. Only when a country has succeeded in setting its own house in order—raised the standard of living of its people, established a stable form of government, shown evidence of technological progress and an enlightened society—only then is it equipped to take a leading part in world affairs.

The force of this argument has been seen more clearly by Sir Anthony Eden's Government than by the mass of people in Britain. We have had full employment for so long that there is no vivid appreciation of the possible consequences of clumsy dictatorship in the Middle East. The dread of war, the betrayal of moral principles, are more potent to the men and women of this country than the risk of having our standard of living drastically cut by the crude exercise of power by an ambitious president. They are right, of course. But if, in the future, we have a return of dire economic hardship, then the emphasis will certainly change.

What, then, is the lesson of the disturbing events since the Israel Army marched into Egypt? From the British point of view, and from the point of view of all highly developed nations, the principle to be established is that the fruits of the technological supremacy which they have achieved by generations of hard work, physical and mental, are not something they are prepared to relinquish in a few years to nations which desire a short cut to wealth. It is true that all prosperous nations live, to some extent, on the cheap labour of less fortunate nations. There is no people more anxious than the British to see standards of living throughout the world raised to the high level which they have shown is possible. Just as socialism internally has narrowed the gap between rich and poor, so enlightened relations between governments can raise the millions at bare subsistence level to a new life in the future. The transition is difficult for countries like Egypt. In education, particularly, they have a formidable task, and many of them need capital from abroad. But the transition will be difficult, too, for Britain and Western Europe, because they must adjust their industries to changing world conditions—or else see their own standards of living drop.

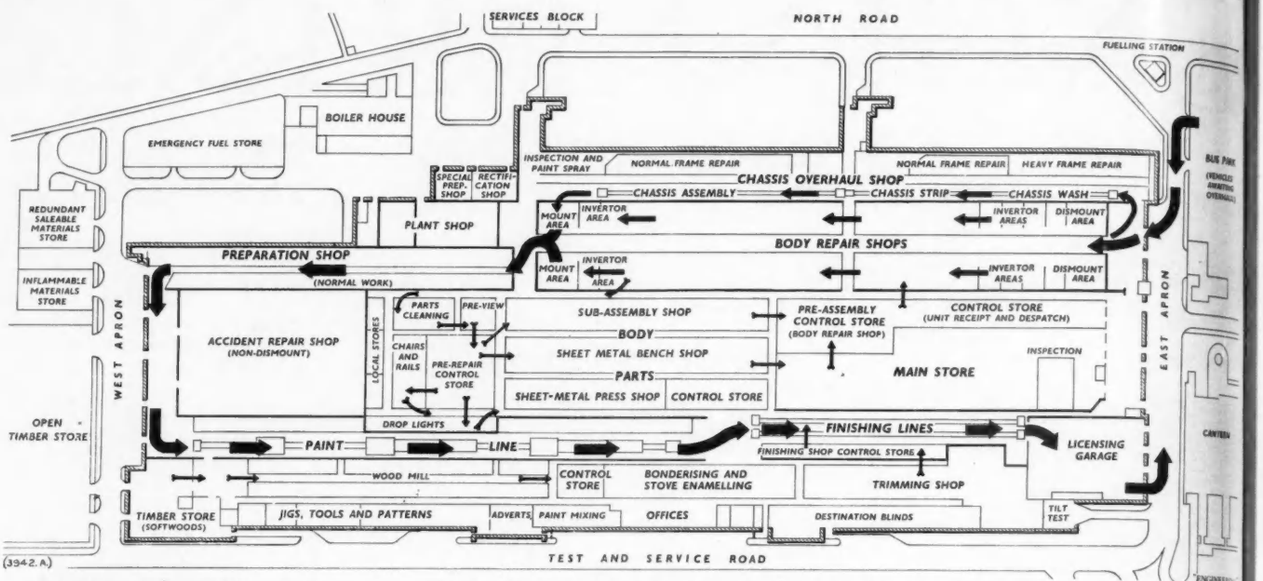

Fig. 1 Overhaul of bus chassis and bodywork has been arranged to follow a flow-line pattern at London Transport Aldenham works.

Plain Words

The Government's urgent request to the Federation of British Industries to obtain industrialists' views on joining a limited free trade area with six countries of western Europe has resulted in what Sir Norman Kipping called "an amber light to go ahead with the proposal." Quite separately, the T.U.C. General Council have given it their conditional blessing. Both the F.B.I. and the T.U.C. hurriedly consulted their members. Many of them expressed, quite justifiably, dissatisfaction at having to commit themselves so quickly on so complex an issue.

Perhaps the most tangible reaction was summed up by the president of the F.B.I., Sir Graham Hayman: "If we refuse to associate ourselves with this plan, we run the risk of a serious degree of exclusion from a great and growing market on our doorstep which in time might also develop into an increasingly potent competitor in Commonwealth and other markets." He described the proposal as daring and far-reaching and said that, to a large extent, its effects are immeasurable. This is precisely the point. No amount of study by industry can yield a reasoned and informed reply. British industry's position is like that of a man on a rock, caught by a mounting tide. He may have any amount of good reasons for not jumping to make the coast. Yet if he stays put he will drown.

The great debate is far from over. Although swept from the headlines by the Middle East crisis it is of far greater importance to this country's economic health than the Suez Canal. Correspondents in *The Times* have sneered at the advocates of British participation as people who are tackling something at the academic and theoretical level instead of the functional. No doubt this must appear so to men whose prime concern is the profitability of their enterprise. They may take a long view, but their vistas are of necessity relatively narrow. Those who govern must consider the political as well as the economic grounds. In 1939, without referendum, Sir Winston Churchill offered union with France. In 1959, union with western Europe may be even more necessary and urgent.

Of the 128 trade associations replying, 52 are "in favour" of the free trade area, given adequate safeguards; 15 declare themselves "not opposed" to further negotiations on it, given safeguards; nine are opposed to it unless very strong safeguards are provided; and 18 are unconditionally opposed. (A further breakdown of the figures is given in Weekly Survey, page 583.) The near-universal insistence on safeguards, which mean different things to different industries, may prove a formidable obstacle to the scheme.

A SYSTEM FOR MAJOR OVERHAULS

FLOW-LINE PATTERN APPLIED IN LONDON TRANSPORT'S BUS WORKS

With a fleet of about 8,000 vehicles (a figure likely to be raised to 10,000 when the change-over from trolley buses is complete) London Transport are faced with an enormous problem of maintenance and overhaul. The original works at Chiswick were only designed to handle a fleet of 4,500 vehicles and consequently they have been considerably overloaded for some years. New works have now been built at Aldenham to take over the general overhauling of bodies and chassis, and the Chiswick works will be confined to maintenance of engines and mechanical parts. The Aldenham works, which were officially opened on October 30 by Mr. Hugh Molson, Parliamentary Secretary to the Ministry of Transport, are sited on the northern side of the Watford by-pass and were originally intended as a depot for the Northern Line extension planned to run to Elstree. There are 17 acres of usable covered space and about 1,800 people are employed, of which 155 are supervisory and administrative staff. A group bonus scheme has been evolved and is working very satisfactorily.

BODY AND CHASSIS SEPARATE

Inspection of the buses is divided into five rotas of different degrees of thoroughness set at intervals varying from every night to once in 36 weeks. In addition, complete overhaul is carried out every 3½ years, and it is this that is done at Aldenham. The engine and some other parts do not lend themselves to interval overhauling at the same frequency as the bodywork and therefore are dealt with on a separate basis. At Aldenham, buses for overhaul are parked outside the works and are then brought in by electric battery tractor to the dismount area (see flow-line diagram, Fig. 1). Here the bodies are lifted from the chassis by an overhead crane and are taken to one of six invertors (three in each line) which turn them on their side to enable the underneath to be cleaned and repaired as necessary. One of these invertors is shown in Fig. 2. The bodies are then taken to the next section, the repair shop, and are placed in bays surrounded by staging, as shown in Fig. 3. The area layout is designed to have 49 of these "stands," of which 45 will be capable of taking double-deck bodies. Seat cushions and any interior fittings needing repair are removed, and such panels as have been damaged in service are replaced. Any other necessary work is carried out and the bodies are removed to another invertor where the undersides are sprayed with Carbolastic paint to preserve them from the effects of road splashing.

Meanwhile the chassis has been taken to the chassis overhaul shop (which runs parallel to the body repair shop) and is attached by a chain to a rope conveyor. The chassis is then washed and stripped as it passes along on the conveyor till it is reduced to the framework. As the amount of repair required by the framework varies greatly from one chassis to another, it is inconvenient to carry it out while the chassis is on the conveyor; arrangements are therefore made to transfer the chassis by overhead hoist to a static bay where the repairs can be undertaken. Repairs completed, the chassis frame is

Fig. 2 After removal from the chassis, the bodies are inverted to enable the underside to be cleaned and repaired.

Fig. 3 To repair the bodywork, the bodies are placed in " stands " and rest on stilts. Handling is by overhead crane using compensated slings.

Fig. 4 Buses are moved from section to section by pedestrian-operated electric battery trucks.

once again placed on a conveyor for assembly. This conveyor is of a type that has been used for chassis manufacture and consists of a series of concrete slabs, each measuring 2½ in. thick by 10 ft. wide by 3 ft. long, which move on a roller track. At the end of the line the slabs are moved vertically downwards and are turned by hydraulic arms through a right angle into a channel running between the roller tracks. The slabs are returned in this position to the starting point at a higher speed, and are then again turned through a right angle and lifted back on to the rollers. At the end of the line the body is remounted on the chassis, which has been sprayed with aluminium paint, and the vehicle is withdrawn by a battery tractor. The assembled body and chassis are given a road test within the precincts of the works, and any rectification required is carried out in an adjacent shop.

INTERCHANGEABILITY

The body mounted is not necessarily the one that was originally on that particular chassis, an arrangement which is made possible by the degree of standardisation that has been adopted by London Transport; indeed, it is only by standardising that such a flow-line method of maintenance as this has been made possible. While the body is in the repair shop it stands on stilts which allow access below it and also prevent the mounting points from distortion during repair. Similarly, on completion of repairs to the chassis, a gauge is applied which checks all points of contact between chassis and body to ensure interchangeability. The repair of chassis and body take up one leg of the U-shaped flow-line which has a total length of 1,000 yards; the second leg is divided into the paint and finishing lines, while between the two lie the main stores and sub-assembly shops for body repairs.

The paint-line conveyor moves in a series of steps of approximately 40 ft. at intervals of about one hour, the movement being under the control of the shop foreman. The buses first pass through a paint-spray booth and then, after touching up and transfer fixing, to the varnishing booths. Each step of the conveyor movement represents a passage forward from one stage to the next. All movement is interlocked with the doors of the paint booths to ensure that the latter are open before the vehicles move forward. Within the booths are motor-driven stagings which enable the operators to reach every part of the vehicles. After varnishing the vehicles are transferred by pedestrian-operated battery tractors to the finishing lines where those interior fittings which had been removed are replaced, and any interior painting needed is carried out, using a roller for paint application. The bus is then removed to the licensing garage where it passes the final inspection before being returned to service. Adjacent to the licensing garage is the tilt test room where both single and double-deck vehicles are checked to ensure that they will not overturn at the angles of tilt laid down by regulations—35 and 28 deg. respectively.

Heating for the works is supplied by a high-pressure water system which also supplies hot water for washing and other process operations. Compressed-air, oxygen, and acetylene are fed from a separate building through channels into the main works where they are distributed as required. An operating economy is that the fuel oil drained from the vehicles on arrival is stored in a large tank and is returned to the vehicles on leaving, so that a balance is maintained. In association with the main plant are: a repair shop for repairing major damage occurring in accidents; and a section for handling seats and cushions so that they can be trimmed, cleaned, and repaired for replacement; for manufacturing destination blinds; for dealing with the wooden parts; and for preparing the sheet-metal parts. New and reconditioned parts used in reassembling the bodies are stored in sets of racks, each set feeding 10 " stands " in the repair shop. Experience has shown that this is an economical ratio. The time taken for a vehicle to pass through the works averages 15 working days and about 56 vehicles can be completed each week.

The standardisation which has made the flow-line principle of maintenance possible can be traced back to the early days of the L.G.O.C. with the introduction of the " K " and " S " type buses. At that time overhaul was required every 12 months. With the formation of the L.P.T.B. in 1933, supervision passed from the police to the Ministry of Transport and the interval between overhauls was extended, mainly made possible by the introduction of the " RT " bus in the late 1930's. By 1949 the interval had increased to 2½ years and the principle of interchangeability of body and chassis was introduced. Now, as mentioned earlier, the interval is 3½ years, except for engines, gearboxes, etc., which are replaced on a "condition" basis by units that have been overhauled and re-conditioned at Chiswick.

CAPITAL ALLOWANCES ON PLANT AND MACHINERY

A guide to the Finance Act, 1956, entitled *A Summary for Engineers and Capital Allowance Supplement* was recently published by the Engineering Industries Association. The provisions of the Budget are explained, in so far as they affect individuals, and the vexed question of the removal of the investment allowance and its replacement by the initial allowance is discussed. The exceptions to this ruling are ships, expenditure on insulation against loss of heat on existing buildings or plant, and plant defined (by orders made by the Treasury) as being in the interest of fuel economy.

The difference between the investment allowance and the initial allowance is defined as follows: " whereas the initial allowance is deductible from the cost of the asset in arriving at the written down value upon which subsequent annual allowances are calculated, the investment allowance is not so deducted." The bonus relief given by the investment allowance is therefore lost. Two examples are given of the application of each type of allowance, based on a 10 per cent. depreciation rate. Where the initial allowance is applicable, the amount of tax recovered on an item of plant costing £1,000 and sold for £400 (net cost £600) is precisely the net cost, namely, £600. On the other hand, where the investment allowance applies—in conditions precisely similar—the amount of tax recovered is £800, i.e., £200 more than the net cost. This is a simple demonstration of the deterrent effect this provision in the Budget is likely to have on capital investment. In many cases, particularly if planned expenditure is taken into account, the effect is already visible (though perhaps difficult to disentangle from the effect of other measures, such as general credit restrictions and increased profits tax).

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FERRITES FOR MAGNETS

Ferrites are chemical components of the general form MFe_2O_4, where M represents a divalent metal, such as copper, magnesium, manganese, nickel, iron or zinc. Some forms which contain two divalent metal radicals, M and M^1 in suitable proportions, possess marked magnetic properties, combined with high resistivities, and during the last few years have been increasingly employed in place of conventional magnetic core and permanent magnetic materials in radio and television equipment and in communication apparatus. Investigations into these materials, which occupy a field where the activities of the physicist, the chemist, the metallurgist and the electrical engineer meet, began in Holland shortly after the war under the supervision of Mr. J. L. Snoek and under conditions the difficulties of which can easily be imagined. Since then, the researches have become international in character and a mass of literature, which can truly be described as tremendous, has grown up on the subject.

The committees of the Radio and Telecommunication Section and of the Measurement and Control Section of the Institution of Electrical Engineers therefore acted wisely in arranging a Convention on the subject, which was held in London last week and was attended by over 100 delegates from overseas. The agenda comprised some 50 papers and covered both the theoretical and practical aspects of the subject. In particular, accounts were given of the discovery of new ferrites with almost rectangular hysteresis loops, which are finding employment as storage elements in electronic computers, while among the microwave applications described were wave guides, the transmission along which can be made virtually loss-free in one direction and subject to heavy attenuation in the other by including in them pieces of ferrite in special positions.

MODELS FOR INSTRUCTION OR EXPERIMENT

UNLIMITED SCOPE WITH FEW CONSTRUCTIONAL PARTS

Models of machinery and other engineering equipment have many uses. They may be made for instructional purposes, for experimental work, as a record of something which has been or is about to be destroyed, or by the skilled amateur simply for the pleasure of achievement. The two latter types of model are usually made to scale, and may occupy a skilled modelmaker, professional or amateur, for a considerable time. The professional engineer, however, is more likely to be concerned with one or both of the first two reasons mentioned, instruction or experiment. The value of models in certain cases is too obvious to need comment, but there are many instances where an engineer has to do without a model, because the cost of producing it by orthodox means would be too high, or because the time required to make it would be too long. Sometimes, especially when it is needed for experimental work, a model has to be made regardless of the cost or time involved, and it may well be that the equipment has ultimately to be scrapped, the value recoverable from the parts being negligible.

It is particularly in cases like these, where the model is wanted quickly and as cheaply as possible, but still has to be robust and accurate, that the FAC constructional kit system, developed by Mark Sylwan, AB., Hornsgatan 89, Stockholm, Sweden, has special advantages. It is, however, in no way limited to such applications; stated simply, the function of the FAC system is to enable accurate, robust models to be built quickly of any kind of engineering equipment. It can incorporate all types of mechanical motion, and is equally suitable for models which are designed for permanent or long-term use, or those which are only intended to have a short existence. In the case of the latter, there is full recovery of the parts for re-use when the model is dismantled. The only tools needed are a spanner and a screwdriver, which are supplied with the kits, and a small vice and hacksaw for cutting rods to length if necessary. Constructional kits are, of course, not new, but the FAC system breaks new ground in its logical design and versatility, which are based on normal engineering practice.

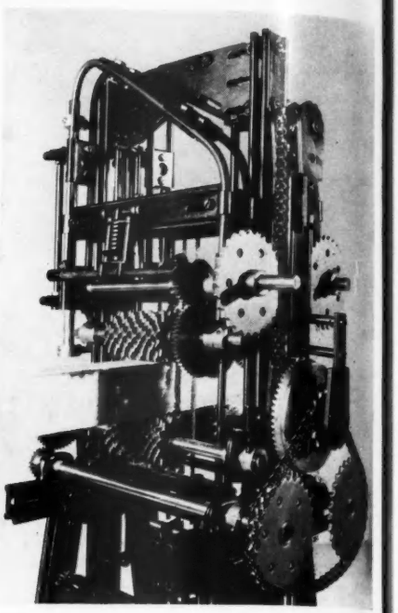
SIMPLE FUNDAMENTAL ITEMS

The basis of the FAC system is a round steel rod, 4 mm. ($\frac{5}{32}$ in.) in diameter, which is supplied in various lengths in the FAC kits. It can easily be cut to length or bent to shape as the particular model requires. Simple pressed steel clips or couplings are used with screws and nuts to couple two of these rods together in parallel, as shown in the acompanying drawing, the distance *a* between the centres of the parallel rods being 7 mm. ($\frac{9}{32}$ in.), which is the module on which the whole FAC system is based, all the components being standardised on this dimensional basis. Cross and T-plates can be used to couple three or four rods in the same plane, and combinations of these plates enable many more arrangements of rods to be connected. The coupling plates are pulled down elastically on the rods, causing a spring-washer effect, so that screws and nuts cannot work loose.

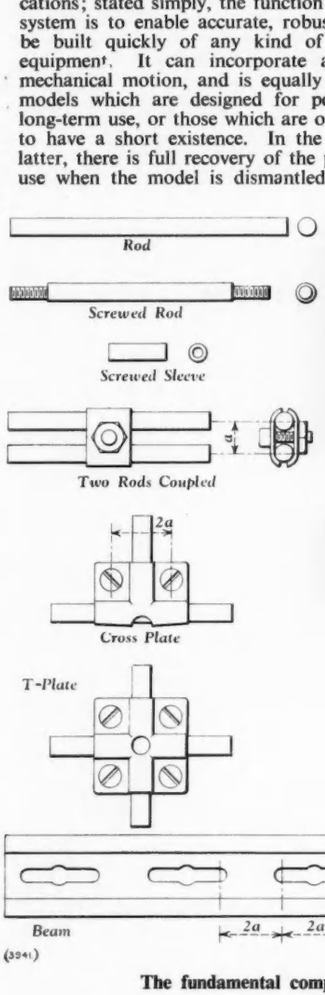
Another standard component is the rod with screwed ends, which mates with an internally-screwed rod or sleeve. The threads are 3 mm. ($\frac{1}{8}$ in.) diameter Metric, leaving the outside diameter of the screwed rods and sleeves the same as that of the solid rods; the components are therefore constructionally interchangeable. By using these screwed rods, or by means of different types of coupling plates, it is possible to couple rods at right angles to each other as well as in the same plane.

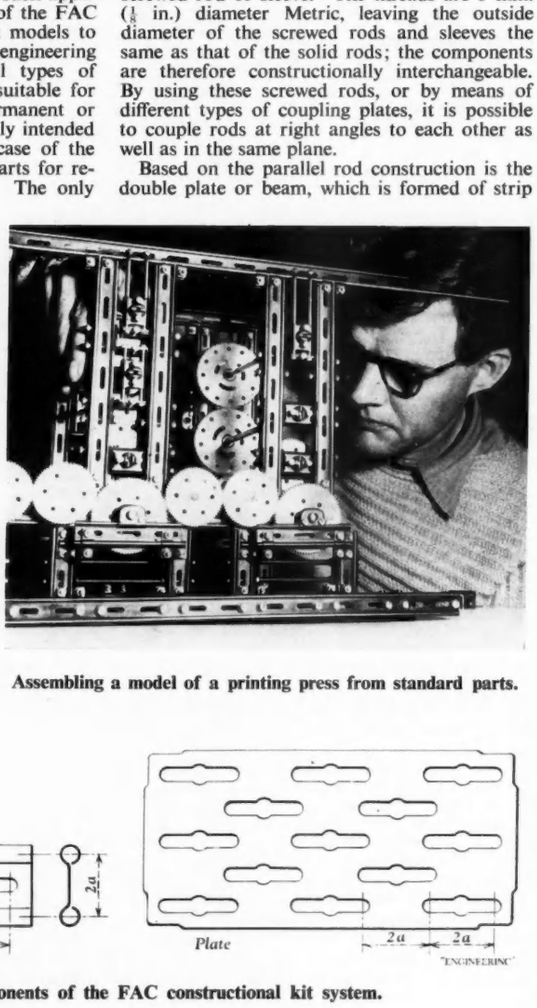
Based on the parallel rod construction is the double plate or beam, which is formed of strip material with the edges turned to tubular form at 2*a* centres (2 × 7 mm. = 14 mm. or $\frac{9}{16}$ in.) The web of the beam is perforated with slots each 2*a* in length and 2*a* apart; standard screws can be passed through the slots for connecting other components. The thickness of the beam web is less than the permissible play between couplings, so the spring clamping effect is assured. A notch in the centre of each slot in the beam permits the passage of a rod or axle.

A further component, the plate, is evolved from the beam; it is, in effect, the web of the beam only. It is supplied in various sizes, square, rectangular or gusset-shaped, and is pierced with staggered slots at 2*a* spacing and of 2*a* length, as in the beam web.



Model reciprocating frame saw, showing a typical application of the FAC system.





The fundamental components of the FAC constructional kit system.

Assembling a model of a printing press from standard parts.

ACCESSORIES INCREASE VERSATILITY

With the small number of simple fundamental parts described, rods, beams, couplings, plates, screws and nuts, it is obviously possible to start building up the framework of a machine or model. Suitable design makes it possible for such frames to carry loads which are very heavy in proportion to the supporting structure. With the addition of a few more standard items the range of the FAC system becomes apparent. There are, for example, a series of tie-rods, consisting of 2·5 mm. ($\frac{3}{32}$ in.) diameter wire formed with an eye at each end to take the standard screw, joint plates for beams at various angles, couplings which enable plates and other parts to be connected in one or two planes, and others for carrying bushes to form bearings for rotating shafts. Brass bushes, spacers and collars are included in the standard equipment, as are pulleys, both single and stepped. Circular pressings are employed, which can be bolted together to form V-belt pulleys. One of these pressings bolted to a second of different form makes a flanged wheel of the railway vehicle type, while a further combination of one inner pressing and two of outer flanged type makes a wheel with a well-base rim on which a rubber tyre can be mounted. There are also several other components, among which may be mentioned a chain wheel and sprocket, together with suitable chain, ratchet wheel, pawl and spring, hooks, helical springs and spring cups.

GEARED ASSEMBLIES

With the components so far mentioned it is possible to build virtually unlimited numbers of models of static form, or with wheels, rotary or semi-rotary, reciprocating or intermittent motion,

but without a range of gears the scope of the FAC would be limited. A set of spur gears is therefore provided as standard equipment, together with bevel gears and a worm and wheel. Ratios of 1 to 1 and 3 to 1 are standard with the bevel gears, while the worm and wheel has a ratio of 1 to 22. Spur gears are available in seven sizes from 16 teeth to 96 teeth, and they can be used in a variety of ways besides the obvious layout of the necessary number of gears in the same plane to give simple power transmission of the ratio required. It is possible, for example, to build, quite simply, a gearbox with two or three forward gears and one reverse, on the principle of the automobile gearbox, or to build differential gears of more than one type, all with the standard components.

The FAC system is available in two standard kits, the smaller, with about 2,400 parts, being designed for both amateurs and professional engineers, while the larger or industrial kit is specially arranged with some 5,000 parts chosen according to calculation based on the frequency with which they occur in the majority of possible designs. Both kits are contained in specially designed wooden cases.

* * *

Letters to the Editor

ENGINEERING RECRUITMENT

SIR, Your leading article on the report on Scientific and Engineering Manpower in Great Britain concluded with the words "Their numbers must be raised; too much depends on too few." This is amply borne out by the estimates of future requirements set out in the report itself, but in neither place is there any reference to the problem of how the skilled youth of the country is to be attracted into the engineering profession in such great numbers. The problem is not new, but it is clearly to become intensified in the years immediately ahead.

Among the principal features which will influence young people in deciding their future career are first, their interest in the subject, second the career prospects which it offers—in terms both of remuneration and management succession—and third, its status in the community. It is one of the great contemporary paradoxes that the contribution of the engineering profession to the future of the country should be so vital, and yet so little understood and acknowledged by the community as a whole. The importance of this contribution is made clear in the report itself, which states:

> "The correlation between increases in industrial output and increases in the numbers of scientists in employment is more than fortuitous. Modern science, whether basic or engineering science, is the source of almost all the ideas on which the development of modern industry depends, and certainly the source of all the more important ideas. We cannot foretell what scientific or technological developments are likely to transform industry in the future; but we can say that scientists and technologists are an essential condition to the healthy growth of industry, now and in the future. Adequate numbers of properly trained men are thus critical for the maintenance and improvement of Britain's present position in the face of increasing technological and business competition from abroad."

It is a truism that the professional engineer in this country does not enjoy the prestige accorded to many of his colleagues abroad, and much more attention will need to be given to this problem of communication if engineering is to earn the respect and capture the imagination of the large numbers of young people who are needed to swell its ranks in the coming years.

The Engineers' Guild is working to secure wider publicity for the professional engineer and acknowledgment of his part whenever reference is made to engineering undertakings; to ensure that salaries are properly related to responsibilities borne and that the highest management posts are open to engineers equally with members of any other profession; and to bring about wider recognition of the status of the profession, through meetings and correspondence in all parts of the country. Engineering lacks prestige and one reason is that hitherto the profession has had no effective public relations organisation. The Guild has recently appointed an experienced public relations adviser and is attacking this problem now, but the measure of its success is bound to be affected by the number of professional engineers who accept the urgency of the problem and are prepared to support the Guild's efforts.

Yours faithfully,
J. G. ORR,
Secretary.

The Engineers' Guild,
78 Buckingham-gate,
London, S.W.1.
November 5, 1956.

* * *

VACATION EMPLOYMENT

SIR, Professor Matheson's letter in last week's issue (page 549) is most helpful to those of us who try to provide opportunities for vacation training.

Two comments on it. Firstly, I am sure there is much more value in learning something about the labour-management situation from below than is generally recognised. I do not think our engineers do enough of it. In Canada and the United States, it is common practice for the vacations to be spent in a construction gang and, in addition, most young construction engineers take the trouble to learn how to drive construction plant. The effect of this is immediately apparent when they come to manage work. Secondly, the use that can be made of undergraduates' (or newly graduated engineers') ability to absorb knowledge fast. Cambridge have done studies on this with mechanical engineering undergraduates and the results were summarised in a most interesting paper to the Mechanicals entitled "An Approach to the Techniques of Graduate Training," by Mr. D. R. Marples and others, early this year. There is need for a similar study in civil engineering conditions.

Yours faithfully,
R. M. WYNNE-EDWARDS,
Managing Director.

Costain-John Brown Limited,
73 South Audley-street,
London, W.1.
November 2, 1956.

* * *

THE SHAPE OF THINGS

SIR, May I reply to Mr. Welbourn's letter in last week's issue, respecting my article published in ENGINEERING of October 19, page 482 ?

From a sculptural point of view, I would describe a catenary as inorganic. It is a calculable, mathematical curve and can, I understand, though I have not had reason to apply it, be expressed as the equation

$$y = \tfrac{1}{2}\, a\,(e^{\frac{x}{a}} + e^{-\frac{x}{a}}) = \cosh\left(\frac{x}{a}\right).$$

Any section of it is, therefore, a logical sequence of its preceding section. The spectator's eye, travelling along its length, is following an expected path and, in common with any other calculable curve, this affords a sense of security and consequential intellectual pleasure.

The curve taken by a full sail is often described as a catenary and though not technically a true one, as gravity distorts the curve that the canvas would take with wind alone, it is still constant enough to be considered a logical mathematical curve. Maybe, therefore, the visual pleasure we get from a well-set sail is not as nostalgic as we might think: perhaps it is an intellectual stimulus.

Yours faithfully,
R. BENTLEY CLAUGHTON.

15 Castelnau,
London, S.W.13.
October 28, 1956.

* * *

INDIAN STEELWORKS

Under the terms of the final contract signed in Delhi on October 31, the Indian Steelworks Construction Company, Limited, London—a consortium of 13 British companies—is to construct and equip for the Government of India a complete and fully-integrated iron and steel works at Durgapur, 110 miles north-west of Calcutta in West Bengal.

We gave, on page 294 of our issue of May 4, 1956, some preliminary information concerning the Durgapur Steelworks. From the data now issued it appears that the iron and steel producing sections of the works will have a rated capacity of 1,250,000 tons of steel ingots per annum and that an annual total of 360,000 tons of pig iron will be available for sale or for foundry use.

The provisional output envisaged for the rolling mill and railway wheel, tyre and axle plant is 790,000 tons a year, to be made up of 100,000 tons of forging blooms and billets, 150,000 tons of billets for re-rolling, 440,000 tons of merchant bars and sections, 60,000 tons of sleepers and 40,000 tons of railway wheels, tyres and axles.

The construction programme provides for the completion of the entire works by August, 1961, but the first and second of the three blast furnaces, with adequate coke-making capacity and ancillary services, will be in operation by November, 1959, and May, 1960, respectively.

Now a village, Durgapur is on the main railway from Calcutta to Delhi and stands on the river Damodar from which the works will draw its supplies of water. Iron ore and coal hauls by rail will be of the order of 70 and 50 miles, respectively, and a large number of special wagons will be provided by the Government of India for this purpose.

The steelworks will cover an area of about 7 square miles and the work of site preparation has already been commenced.

* * *

BRAKE ON A SATELLITE

An electrical braking force, the existence of which has been proved by Dr. Bo Lehnert, of the Stockholm Polytechnical Institute, is likely to threaten the experiments with the satellites that are to be sent out into space during the International Geophysical Year 1957-58. The Swedish scientist's findings have led to an extensive correspondence with the American research workers who are planning the satellite programme,

According to the Swedish calculations the satellite will be electrically charged when bombarded by electrons and ions during its passage through the ionosphere. This charge will in itself have a retarding effect on the satellite—to what extent it is not possible to estimate at present—and also give rise to an electrically charged "wake" with unforeseeable effects on the satellite. The cautious wording of Dr. Lehnert's comments on the calculations runs: "Should it prove that the satellite does not behave in the manner foreseen, the electrical charge may offer part of the explanation to the deviation."

From Dr. Lehnert's correspondence with the American scientists it looks as if they had not previously paid attention to this phenomenon. The current research work at the Institution for Electronics of the Stockholm Polytechnical Institute has opened up many aspects related to this problem.

Weekly Survey

Cover Picture: *The tubular elements for a vertical forced-air-circulation tempering furnace are shown being welded. The furnace, which operates up to 700 deg. C. and is used for heat-treating both ferrous and non-ferrous metals, consists of a cylindrical heat insulated chamber with an inner concentric metal baffle. The heating elements are arranged in an annular space between the baffle and the refractory brickwork. A centrifugal fan in the base creates high-velocity air circulation; the convection currents are directed through the space between the baffle and brickwork, over the elements and so down to the charge.*

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Challenge to the Radio Industry

It is only a few weeks since the price-control arrangements of the British radio and television-tube manufacturers came to an end after 30 years. From now on the industry is embarked on the perilous but by no means forlorn seas of competition. How this will work out for users of valves is an open question, for price control has come to an end at a time of rising costs. The hallmark of competition is likely to be not so much a reduction in price as a delayed or discriminating increase.

Some idea of the growth of the industry was given last week by Mr. G. A. Marriott, in his address[1] as the newly-elected President of the British Institute of Radio Engineers. Mr. Marriott pointed out that the radio industry's total annual turnover, presumably excluding radio and electronic equipment for defence, is about £300 million. Its annual export figure is over £40 million. In 1924 this country produced 2½ million valves; in 1938 the figure was 12½ million and last year it was over 64 million. Valves for industrial purposes have played an important part in this expansion. In 1955 there were five times as many valves made for broadcast entertainment as in 1938, seven times as many for the Services and 30 times as many for industry. In 1938 the industry was producing 10,000 cathode-ray tubes a year, whereas the current rate of output is 2¼ million tubes a year. Mr. Marriott thought that the use of the transistor would not materially affect the demand for valves for many years but he hinted that when the transistor could be made by really mass production methods its challenge would be exceedingly serious. The basic materials in a transistor cost only 1/20th of the basic materials of a valve.

It is not surprising that the President should have emphasised the shortage of engineers in the radio industry. A shortage of engineers is now an occupational hazard for all managements in industry. Fortunately for radio it is a new industry as age goes in these matters, and new industries are usually able to afford terms which are much more attractive to youngsters and technicians than some of the older ones. To that extent, the radio industry is faced with a less intractable man-power problem than some of its older and august relatives.

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Ebb Tide?

The feeling is growing throughout the country that the recession may have passed its worst. This is notably so in the Midlands, which has felt the brunt of the credit squeeze owing to its impact on the motor-car industry. This feeling of optimism should be kept within bounds however. Apart altogether from the implications of the latest phase of the Suez situation, which can only develop as that situation itself develops, there is plenty of sting left in the credit squeeze in its impact on house building and the constructional engineering trades. It is now certain that constructional work, which is always a critical factor in boom and slump, will be slowing down next year and that this will act as a brake on industrial expansion.

The latest figures of industrial production suggest that industrial activity on the whole continues remarkably stable. The official index number for industrial output, which is based on 1948 as 100, is provisionally estimated at between 139 and 140 for September. This compares with 140 in September, 1955, and with 115 for the holiday month of August this year. The Central Statistical Office has revised some of its earlier estimates slightly upwards. The increase in production during the first nine months of this year, compared with the same months of 1955, is rather less than 1 per cent. This stability was achieved, of course, as the result of a number of component indices moving in opposite directions. Activity in the capital goods industries was still increasing in the first nine months of the year while consumer durable goods fell back. It would appear, however, that early suspicions were correct that the foodstuffs industries reaped more in the way of man-power and increased demand for their goods from the recession of motor vehicles than did the capital goods industries.

If the recession should, in fact, be losing its impetus, it is going to be difficult to assess what it has achieved. Unskilled and inefficient labour has been shed (though there are signs that it is finding its way back), but there has been no noticeable switch of semi-skilled and skilled labour into those industries which need it most in terms of the national effort, with the possible exception of the machine tool industry. It is beginning to look as though the recovery from the recession is going to be more protracted than might at first have appeared, but that industry as a whole may decide that the worst is passed and make its plans of expansion accordingly. Into this rather delicate state of business confidence there now is to be injected the impact of the fighting on the Suez Canal. Hostilities there may play a highly important role in the state of business activity and confidence, without there being a large-scale industrial mobilisation to meet the emergency.

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Action on Effluents

Disposal of effluent from industry is a pressing problem. The increase in the number of actions at common law against industrialists for alleged river pollution made the Federation of British Industries set up a special panel of its Technical Legislation Committee to look into the matter. The problem has become increasingly urgent since about 1949 owing to the difficulty of dealing with detergents which have been a problem at sewage works and to the general increase in industrial activity, not least in the chemical industry.

A certain urgency has been given to the question because under the Rivers (Prevention of Pollution) Act, 1951, river boards will be able from 1958 onwards to seek injunctions restraining drainage boards from causing pollution. Similar action will be taken by the drainage boards against local authorities if the effluents they pass on are impure enough to cause pollution. This has led local authorities to encourage manufacturers to put in their own plants to purify wastes. The problem of dealing with polluted effluent has all along been one of cost, so far as industry is concerned, as it is possible for a treatment plant to cost anything from £250 to £250,000, depending on the circumstances. The size of the problem can be illustrated by the Birmingham area, where the volume of trade effluent now accounts for between 35 million and 40 million gallons of the flow of liquid through the sewage, which in total amounts to between 70 and 75 million gallons daily. This represents something like a doubling of the output of effluent in the last eight years.

It was announced last week that the Central Advisory Water Committee has decided to set up a special sub-committee on the subject. Its terms of reference include the examination of existing legislation and the operation of the common law on the disposal of effluents. It is to look into the problem, including the financial difficulty of providing plant, and to consider whether farms or other premises should be designated as trade premises for this purpose. The special problems of radioactive effluent are specifically excluded from its directive. The committee is also asked to look into the 1951 Act and see whether there should be an extension of the seven-year interim period before the powers of injunction already referred to can be brought into operation. The easy recommendation would be to buy time by suggesting the extension of the interim period, but the problem is becoming so urgent that it is hoped the committee will produce some constructive suggestions. If the financial problem is the critical one, there are already precedents on fuel efficiency which might be invoked in this case as well.

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Crime Pays at Sea

A judgment was given in the High Court last week which shows the nonsense which can be made of the law when inflation and the non-observance of international conventions operate together. In this case, *St. John Shipping Corporation* versus *Joseph Rank Limited*, judgment was given for the plaintiffs (who are incorporated under the laws of Panama) in their claim for £2,000, the balance of freight due for the carriage of wheat in the S.S. "St. John" from Mobile, Alabama, to Liverpool at the close of 1955. The ship called at Florida on the way back to bunker, thereby submerging her summer load line by 10 in. On arrival at Birkenhead her winter marks (she had entered the winter zone during the voyage) were submerged by 11 in. The master of the ship was prosecuted and fined £1,200. The defendants, at the request of the charterers, withheld part of the freight due, contending that the charter had been performed in an illegal manner.

Under the Act, which was passed in 1932, the maximum fine is £100 per inch of overload. The ship under consideration was over loaded by 427 tons and the extra freight earned was £2,295. This was almost double the fine. There was a series of complicated legal arguments in the case about the defendants' right to withhold a part of the freight, thus bringing commercial pressure to bear in a situation where the law was obviously inadequate. The two points which may be noted here are that it was a paying proposition to overload the ship but that, on the other hand, if the master had been British he could have been imprisoned for the offence.

It is clear that with the serious depreciation in the value of money over the last 24 years, the financial deterrent under the Act of 1932 has been lost. Furthermore, the ability of foreigners to avoid criminal proceedings under British law, so far as the running of their ships is concerned, is one more illustration of the present highly unsatisfactory state of international conventions on shipping.

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Bearings' Smooth Performance

No industry has reflected the divergent trading experience of motor-cars and commercial vehicles more than the ball-bearing industry in the last year or so. Ball-bearing manufacturers are heavily dependent on the motor-vehicle industries, but the sales performance of commercial vehicles has been of inestimable value to them since the recession in car output developed last autumn. British Timken Limited reported higher

profits in 1955 than in 1954 and Hoffmann Manufacturing Company Limited reported a good year last April. Last week, Ransome and Marles Bearing Company Limited held their annual meeting and reported higher profits in the year ended June, 1956.

It is not likely that the industry as a whole will get away unscathed from the motor-car recession. The companies' chairmen have pointed out that more difficult trading difficulties may be experienced in 1956 than in 1955. After all, the recession in the motor industry has taken some time to work itself out on the ancillary industries—much longer than had been expected. The ball-bearing industry may therefore have things slightly worse before they get better. Some of the larger companies, however, are far more dependent on the demand for roller bearings, and here the modernisation of British Railways will continue to provide a worthwhile market for a number of years. On the other hand, the growing use of precision bearings in machine tools, and the significant replacement demand for ball bearings which is bound to build up as horse-power per worker increases, provide good long-term prospects for the ball-bearing side of the industry and some expectation that dependance on motor vehicles may become slightly less marked.

The industry itself is clearly optimistic. Ransome and Marles have been running-in new capacity and British Timken are going ahead with the next stage of their development programme. It will be recalled also that Hoffmann announced in the spring that they would be continuing with their programme of capital development.

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Full Steam Ahead

Last week's batch of annual reports from engineering companies was outstanding in quality and confidence in the future. Most were for years ending June 30, but the chairmen took their review of events right up to date and based their assessment of their companies' prospects on the latest available information. Those of William Doxford and Sons—builders of ships and marine engines—and of Carrier Engineering Company, Limited—who have gone far in recent years in the production of advanced mechanical handling plant—were perhaps the most cheerful.

Dr. E. P. Andreae, chairman of Doxford's, reported an increase of nearly £¼ million in profits, and very satisfactory results from the schemes of re-organisation, re-equipment and extensions on which the company have been engaged over the past few years. Production has been considerably speeded up and there is hope that the order books—"as full as we would like to see them"—will be even more vigorously attacked and the time lag reduced. The British shipbuilding industry certainly needs this kind of outlook. New products are emerging from the company's extensive research and development: "A new experimental engine will shortly be running in our shops"; "the first large supercharged Doxford oil engine to be built by us is expected to be on test early next year," and the company's diaphragm oil engine, designed to burn the heavier fuel oils, is now standard practice. Dr. Andreae has good cause to remark that "so far as anyone can judge, the outlook is very promising." The only handicap appears to be a shortage of skilled labour.

Carrier Engineering also report a substantial increase in profits and a satisfactory long-term order book which Mr. Stanley Groom, their chairman, says "should ensure for us a progressive rate of output and so tend to compensate for the ever-present problem of rising costs and narrower profit margins per unit of sale." In their case, the size of orders now being taken (some individually equal to more than double the issued capital) have made new capital essential and £200,000 have been capitalised out of retained profits. Other companies rapidly forging ahead are Lancashire Dynamo Group and Monopumps Limited. The former have acquired J. A. Statter and Company, Limited, who make electrical switchgear, to extend the group's interests in the industrial electrical equipment field—described as "a rapidly expanding market at home and abroad." Monopumps have purchased factories in Johannesburg and Melbourne because the sale of their products in South Africa and Australia "has grown sufficiently to warrant an extension of our activities in these countries."

Linotype and Machinery, Limited, a subsidiary of the Merganthaler Linotype Company, New York, also report a programme of vigorous expansion and modernisation. Mr. V. E. Walker, the chairman, has reported an increase in net profits of nearly 9 per cent. to £723,000 and—although he complained of an acute shortage of machinists and design staff, cancellations of orders due to the Government's credit squeeze and restrictions on hire purchase, worldwide monetary restrictions and other difficulties—he was able to say "the present state of our orders for all classes of our machines . . . remains satisfactory." All these companies have a success story to tell.

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Hurdles for Companies

Four important companies reported a year of considerable strain, mostly arising from the Government's policy of credit and hire purchase restrictions. In their case, however, they survived remarkably well: all showed higher profits. They are Qualcast Limited, known mainly through their production of lawn mowers but in fact the largest producers of iron castings in Europe; Ransome and Marles Bearing Company, Limited, whose sales of ball and roller bearings are mainly to the motor vehicle and durable consumer goods industries and who are referred to in the note "Bearings' Smooth Performance"; Roneo Limited, manufacturers of a wide range of office machinery and supplies; and the Spurling Group (Spurling Motor Bodies Limited) who, as their name implies, make vehicle bodies. All have in common a fairly heavy reliance on industries manufacturing consumer goods (if cars can be so described).

Qualcast's chairman, Mr. J. E. V. Jobson, tries hard to underline that his company do not just make lawn mowers: "our lawn-mower production is the largest in the world so far as we know, and is a very important part of our activities, but it is several times outweighed by the trade of our foundries, where we produce somewhere around a million castings a week." Turnover increased by 9·7 per cent., profit (before tax) by 3·8 per cent. The increase in sales was inadequate to offset rising costs, but this company have progressed so far in mechanisation in recent years that the optimum economies of scale may well have been reached. Falling orders from motor-vehicle and refrigerator manufacturers caused short-time working but there has recently been some improvement and "the end of December should see us working at capacity again."

Ransome and Marles also record a satisfactory increase in turnover and profits, though margins were much lower. Mr. Edward W. Senior, the chairman, said that "the order book now stands at a higher level than a year ago" but warned that to ensure continuing gains in productivity means ploughing back profits to acquire "the most efficient and up-to-date plant obtainable for our purposes" and that the benefits which should flow from the increases in productivity "will be nullified if, as has been happening, wage increases more than cancel these reductions (of manufacturing costs)." Mr. W. F. Spurling is full of hope for the future, despite the cuts in motor-vehicle production of the past few months. "We are in good heart," he said, "our expansion programme is proceeding according to plan." Spurling's association with Vauxhall (they fit their bodies to the Bedford vehicles) and also with Rovers and Scammells doubtless stood them in good stead.

Sir Greville S. Maginness, chairman of Roneo, also complains of the effects of the credit squeeze on home sales, and of currency difficulties in export markets. But he reserves his big guns for the unions' wage demands, which have "understandably given cause for both surprise and serious concern." He chides T.U.C. leaders for their unwillingness "to accept the responsibility which clearly rests upon the trade unions." The need to halt inflation is underlined and the current situation analysed at some length in his annual report. Sir Greville wants to see more private investment from savings and more investment generally.

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Mixed Blessing

Comments on the plan for a Western Europe free trade area received by the F.B.I. from the metal and engineering industries suggest that they would welcome "competition on equal terms" but some fear that such terms "will not be realised in the event." Few of those who rely to a marked extent on exports to the Commonwealth, would be prepared to see the progressive whittling away of imperial preference accelerated. They would want strong protection against dumping, and a guarantee that subsidies, overt or hidden, would not be tolerated. The difficulties of ensuring this where strategic industries are concerned—such as the aircraft or atomic energy industry—are formidable, though in these cases the advantage would probably lie in Britain's favour. An essential condition of any workable scheme would be to provide for the greatest possible liberalisation of payments and capital movements. The incidence of taxation and the permitted rates of depreciation would have to be comparable for all countries in the area. On the present basis British engineering could hardly hope to compete on equal terms. In this respect labour costs are all-important, implying comparable rates of pay, hours of work, paid holidays and the cost of social security and other welfare services.

Of the 15 associations in the metal manufacture and metal goods industries, three were unconditionally opposed to the conduct of negotiations: British Ironfounders' Association, Sheffield Lighter Trades Association, and the Woven Wire Manufacturers' Association. The Council of Ironfoundry Associations were unable to reach a decision in time; as were the National Brassfoundry Association. Those associations unconditionally opposed to the scheme in the engineering and vehicle manufacturing industries were limited to the Locomotive Manufacturers Association, the British Constructional Steelworks Association, and the Federation of Surgical Instrument Manufacturers.

Among the supporters of the scheme—in favour, provided certain safeguards are worked out—were the steel industry, the aluminium industry, makers of internal-combustion engines, agricultural machinery, scientific instruments, printing machinery, steelworks plant, radio and electronic equipment, electric lamps, hydraulic equipment and aircraft. They include most of the "growth" sections of British engineering, which already contribute heavily to the country's export drive in world markets. Some of these industries are also listed under the category which "do not oppose" further negotiations assuming safeguards are worked out.

Their fears are unlikely to concern other than their German competitors, and it is natural enough that they should want to compete on equal terms. Of the non-federated firms 251 declared themselves in favour, 59 against and 20 could not reach a decision.

On the whole, therefore, the British metal and engineering industries have given the Government a moderate measure of encouragement. Not quite a green light perhaps, but nearer to green than to red.

THE COST OF VARIETY

The case for the co-ordination of design, production and sales in an engineering works presented by Engineering Information Service—an organisation recently set up by ENGINEERING. *Details of E.I.S. are given on page 29 in the advertisement pages.*

Variety and excessive complication of designs are old enemies of the production engineer. They prevent him from using the most up-to-date methods of flow layout and automatic transfer. They make machine loading difficult and machine utilisation inadequate. In fact, they prevent the production engineer, and his colleagues in the planning and production control departments, from exercising their proper functions. Unnecessary variety and excessive complication cost money. In this context two quotations from authoritative bodies are apposite. The Institute of Cost and Works Accountants' excellent little book *Cost Reduction* comments: " Probably the greatest scope for cost reduction throughout industry lies in the field of product design. Costs at all other stages in the life of a product may be considerably influenced by decisions taken at this point. The design function, therefore, offers an extremely important area for cost reduction action before tools and fixtures are ordered, material purchased and orders released for manufacture." The serious implications of the maintenance of an excessive variety of components and end-products are underlined in the British Productivity Council's Action Pamphlet on *Simplification in Practice*:

" Much evidence has been gathered together that a vigorous campaign of simplification, prudently applied, would greatly improve the competitive powers of British industry. . . Many firms are losing ground by persisting in the production of too many varieties. Too often a few products manufactured efficiently with adequate profit margins have to carry the hidden losses of many others which ought to be improved or dropped. Too often there is not enough staff or time to tackle the improvement of a wide product range."

The significance of the words " prudently applied " should not be overlooked. The simplification of design is not a cure for all a firm's problem, any more than an incentive scheme is a substitute for good management. We shall not attempt to say in this article " so away with all variety; restrict your range to one or two standard products." For many precision engineering concerns, who over the years have built up good research and development resources and evolved efficient but flexible methods of production, to do that would be a shocking waste of talent and know-how. Yet the fact remains that innumerable concerns—among them some highly profitable ones—are unable to produce efficiently owing to their having too varied a range, particularly of components. This applies with special force to firms where plant can be re-set and used for a number of different manufactures. There are also far too many specifications which were evolved years ago and therefore do not incorporate the latest materials. Too many designs are the expression of a personal idiosyncracy, that of a designer or of a user of the product.

The solution lies in an attitude of mind. The promotion of an inquiring and dynamic approach—not only in the boardroom and the design office but also in sales, purchasing and finance—will go far towards it. The basic need is for a healthy questioning of what is, and a lively interest in what could be.

THE ROOTS OF VARIETY

Extensive investigations among engineering concerns show that variety is greatest in those with a long history of technical pre-eminence. Often the firm was started by an enthusiastic young designer who gathered around him like-minded people. They did not go out to sell a product or a range of products but their brain-power. Every order was executed as a new design, or as a variation on an existing one. This " one-off " or " tailor-made " habit stuck and coloured the firm's outlook throughout their growth. The fact that design has a production function and a cost significance was never properly appreciated. Yet no old design was ever discarded. Drawings, patterns, works orders, spare parts and even models clutter up the firm's filing space and stores.

Another major contributory factor is the ineffectiveness of a sales department whose staff make only half-hearted attempts—if they make any attempt at all—to sell what the firm makes. The readiness to agree to incorporate the preferences of customers—who may number 2,000 or more, spread throughout the world—is a weakness abundantly reflected in the product or component range of many engineering companies. Often this could have been avoided if the salesman had been aware of his own company's standard range of components and willing to put to the customer's engineers the cost and other advantages of accepting a catalogued item. Increasingly companies are endeavouring to evolve a range of standard component units which can be " tailor-fitted " to particular applications, but they are in the minority.

DESIGN SIMPLIFICATION

The simplification of a company's existing range of designs requires a systematic and thorough investigation of each one. Each component should come under scrutiny and be put to a number of simple tests. The listing of part numbers and descriptions and the grouping of like parts is a useful starting point. The movement of each part will provide some guidance: those that sell persistently at low volume should be segregated and considered in the light of their true cost to the business. But slow movement could mean that selling has been ineffective, or that the sales price is badly out of line with that of competitors.

Such a review should be highly critical. In the United States ten simple questions are used to establish the features of component and assembly design and to determine how they could be improved to yield a reduction in production costs without impairing quality or saleability. The British Productivity Council's *Design for Production* illustrates this method. Each part, whether made by the firm or bought out, should be submitted to the following questions:

(1) *Does its use contribute value ?* A condenser was used across contacts of a relay to provide arc suppression as contacts open. When cobalt became available again an alnico magnet was devised to provide a snap action, making the condenser superfluous.

(2) *Is its cost in proportion to its usefulness ?* A steel spacer hub was used for mounting light aluminium discs, under-cut to reduce weight. It was established that by making the part of aluminium the under-cutting could be eliminated, without impairing performance, but further reducing the weight and yielding a saving of 80 per cent. in unit costs.

(3) *Does it need all its features?* A stainless-steel washer in a dispensing unit was chamfered on one side. By eliminating the chamfer, which was known to add nothing to the washer's value, a saving of 72 per cent, was made.

(4) *Is there anything better for the intended use ?* A mica stack was used for insulation; by changing to a Micalex moulding a more rigid assembly and a 15 per cent. saving resulted.

(5) *Can a usable part be made by a lower cost method ?* A hub assembly was designed and made as a two-part riveted or staked assembly. By using a casting the assembly operation was eliminated and a saving of 67 per cent. obtained.

(6) *Is it made on proper tooling, considering the quantities used ?* A stainless weld nipple once required in small quantities was made from a standard fitting, machined to provide the desired weld embossing. Investigation showed that the quantities sold warranted making it on an automatic screw machine. The saving in cost was 75 per cent.

The other questions relate to bought-out components, and place considerable emphasis on a well-directed, intensive purchasing search as well as on the need to fall in line with the standards of suppliers: *Can a standard product be found which will be usable ? Will another dependable supplier provide it for less ? Is anyone buying it for less ?*

Asking such questions is little more than applied common sense; yet it is surprising how much is taken for granted in a business and how few pertinent basic questions of this kind are asked once the design specifications of a component or an assembly have been established. To ask them takes a great deal of courage—for someone is always there to rise in defence of the *status quo*—and to provide objective answers takes time which is hard to find against the pressure of day-to-day business. Yesterday and to-day—tradition and routine—are the enemies of design simplification. There is little hope of achieving it without (*a*) a well defined design policy and (*b*) machinery to carry it out.

CO-ORDINATION OF DESIGN

During the post-war period, major successes in the engineering industry have been won by companies who have applied their research, development and production resources to the engineering of complete systems. These might be mechanical handling, hydraulic units, process control, measurement and recording, vacuum techniques or other systems with wide industrial applications. The essential features of most of these are basic design principles and practices, a comprehensive range of standard components and great flexibility in applying the principles and " tailor-fitting " the components to particular applications. The successful execution of such a policy depends almost entirely on good design co-ordination and team work. Several companies have achieved this by means of a design co-ordination committee, composed of the heads of the departments concerned, say design, finance, production, purchasing and sales.

Apart from establishing the basis of design policy, such a committee can instigate investigations into existing designs in order to determine their value and to see how they measure up against new developments. The representation of all major departments ensures that the company's design policy is well understood, and that the point of view of the men who have to make and sell the products is known to the chief designer. This " team " approach to design is a practical solution to the general—and in the normal sense inevitable—conflict of views between design, production and sales. It has the added advantage of bringing them into contact with purchasing—a key department in any product simplification scheme where understanding and co-operation are essential prerequisites—and with finance, normally responsible for costing in all its varied aspects. Under the leadership of the head of the firm a design co-ordination committee can achieve the unity of purpose indispensable to the implementation of design policy.

The simplification of design and the co-ordination of design policy are difficult to achieve without up-to-date information. The need for this ranges widely. It includes developments in the fields of research, of design, in manufacturing techniques or processes for which the products are used, in the technology of materials and their availability, information on the progress of competitors, price levels, and other factors. New ideas and new products, whether an addition to the range or an extension of it to other fields, require objective market information. Only rarely are the combined virtues of business acumen, practicability, and creative genius found in one man. But even a team of able executives must have facts—technical, financial and commercial—to carry on an informed discussion on design and arrive at sensible conclusions.

ENGINEERING CONTRACTS

8—UNDERGROUND WORK AND THE UNEXPECTED

By F. H. B. Layfield

This is the eighth article of the series being contributed by Mr. Layfield for the guidance of engineers and others engaged on the preparation of engineering contracts. The seventh article appeared in ENGINEERING, *October* 26, 1956, *page* 521.

Because of their very nature, engineering projects often involve substantial work below the surface of the ground. The installation of water supply and drainage systems are leading examples of such projects but, of course, a great many other schemes also involve work below ground. It is never very easy to predict exactly what conditions will arise when work is carried out entirely above ground, and it is incomparably more difficult to predict what will occur below. Moreover, difficulties arising below ground are often much more expensive and sometimes more dangerous to deal with than are surface problems. It is not surprising, therefore, to find that difficulties met with in work below ground are often the cause of disputes between the parties to an engineering contract. The problems involved are chiefly technical ones, to be dealt with by engineers, geologists and others. Nevertheless, careful consideration of certain of the legal aspects of underground workings can help the engineer to avoid some of the pitfalls.

When the contractor undertakes work above ground he is usually expected to satisfy himself about prevailing conditions by inspecting the site. He will then enter into a contract after the site inspection and will usually be liable, thereafter, for anything unexpected which occurs. When the contractor is to undertake substantial work below ground, it is usual to make special provisions to deal with conditions which may be met with unexpectedly. In any event, in normal circumstances, the contractor is still placed under an obligation to make a thorough inspection of the site and to anticipate what conditions he may reasonably expect to find. But most printed forms of contract provide that, where unexpected conditions are met with, special contract provisions shall be brought into effect. The first problem to decide, therefore, is when may conditions be described as unexpected ?

GEOLOGICAL SURVEYS

When the work underground is to be of considerable extent or quantity, a geological survey will often have been made previously and the results of boreholes may be available. If the engineer desires, and feels able, to rely upon this survey he may be well advised to make the survey report a contract document, with the result that, if the conditions met with could plainly have been foreseen from the findings of this survey, that will usually settle the matter. It may also be worth considering whether or not a reference to the survey should be made in the conditions of contract. The reliability and adequacy of the survey are not the only preliminary problems to be faced, as the experience of the contractor may also be a relevant factor. The Institution of Civil Engineers' General Conditions provide that special arrangements shall apply

> " If . . . the contractor shall encounter physical conditions . . . or artificial obstructions which . . . could not have been reasonably foreseen by an experienced contractor . . ."

and provided also that these unexpected conditions involve extra work and plant. This is probably the best provision that can be made in a standard form for general use, yet an endeavour to decide what, in any particular set of circumstances, constitutes an experienced contractor is an exercise likely to raise more problems than it solves. There is something to be said for the view that the fact that the contractor has been employed by the employer is, in itself, reasonable evidence that he is regarded as sufficiently experienced. If it is desired to call in question the skill of the contractor in foreseeing underground conditions some more objective test should be selected by the engineer.

The Institutions of Mechanical, Electrical and Consulting Engineers have tackled the problem of what is to be regarded as unexpected in a different way. In their "A" and " B3 " forms, they provide that extra payment shall be made if certain enumerated obstacles are encountered

> " Where the actual conditions of the ground are not stated in the contract and could not reasonably have been inferred from an inspection of the site by the contractor before he prepares his tender."

This form of words, however, has two obvious difficulties. In the first place, it may often happen, particularly in the case of very extensive works, that very little could be inferred from a mere inspection of the site. This may have the result of making the employer liable to pay much more in extras than was anticipated. It may also offer little encouragement to the contractor to ascertain with care what conditions may arise below ground on the site. In the result, there may be disputes which more careful anticipation might have avoided. The second difficulty with the "A" and " B3 " forms in this regard is that it may not always be easy to decide what amounts to a statement in the contract of " the actual conditions of the ground." Indeed, it will surely not be often that the employer will be prepared actually to state what are the conditions of the ground below surface level.

ADVERSITIES AND OBSTRUCTIONS

The course which, perhaps, will appeal most to the employer and the engineer, and be the most reasonable also, is to relate the problem to the survey findings. Such a procedure involves making the usual general provision that conditions below ground shall be regarded as unexpected when they could not have been foreseen. This is then qualified by stipulating that the conditions must not have been foreseeable having regard to the findings of the survey, or of the borehole results, or of some similar factual statement. It is true that even this arrangement is not absolutely clear but it is probably the best that can be achieved with so intractable and uncertain a problem.

Once it is decided that underground circumstances are unexpected the next difficulty to be decided is what can properly be regarded as an artificial obstruction or an adverse physical condition. The Institution of Civil Engineers' General Conditions merely name them as such, while in the "A" and " B3 " forms they are enumerated. These forms provide for extra payments to be made

> " If rock, rocky soil, solid chalk, water, running sand, slag, pipes, concrete or other obstructions are found, or if it should be necessary to leave in timber, or provide support for existing works. . . ."

provided always that the presence of these could not reasonably have been inferred. There is some value in thus enumerating what are to be regarded as underground hazards which will give rise to a claim for additional payment. If this is done it may well be that the contractor must take the risk of encountering during the progress of the work anything not listed. On the other hand, the advantage to the employer of enumerating the hazards for which he will pay is largely lost if the list is followed by such words as " or other obstructions," since this addition may easily embrace almost anything. It would seem that, normally, the engineer will be well advised to leave the matter of what constitutes an underground hazard, for which payment will be made if it is encountered, in fairly general terms, as in the Institution of Civil Engineers' General Conditions. If, on the other hand, he elects to enumerate those hazards then he should not add a general class at the end of his list.

DEMANDS FOR EXTRA COSTS

The next important problem is to decide what procedure should be followed when the contractor encounters unexpected physical conditions below ground and for which he desires extra payment. There are three essentials for the engineer at this stage. First and foremost, the engineer will normally wish the work to continue notwithstanding the appearance of an obstruction. He may desire to do this by avoiding the obstruction and, in a well drafted contract, his powers to make a suspension order and, or, a variation order, should be adequate. It should be unnecessary to make special mention of these powers in the clause dealing with underground works. In this regard, the engineer may do well to satisfy himself that whatever notices may be required to be given when an obstruction is met with, this process should not entitle the contractor to stop work unless the engineer so desires. Furthermore, the engineer will wish to see that the contractor is required to give immediate notice when he has met adverse conditions and provide sufficient details in that notice so as to enable the engineer to judge what should best be done. The contract draftsman will wish to know what these details should be.

Secondly, the engineer may be very harassed at the moment when unexpected events occur, as, for example, when water under pressure has been encountered below ground. He may wish, therefore, not to be obliged to decide difficult questions of liability when he is giving orders for work to be continued or to be varied. Accordingly, the procedure set out in the contract should permit the engineer to accept quotations for the additional work involved and to give appropriate orders without an admission of the employer's liability for payment for the work concerned.

Thirdly, the engineer will wish to receive a detailed record of events and, particularly, of the costs incurred, so that, with the assistance of this information, he may later judge the question of the employer's liability, or otherwise, and the extent of any such liability. For this reason, the contract should provide for the contractor to supply the engineer with appropriate details as work proceeds. Here again, the draftsman will wish to know what these details should be, so that they may be set out, where appropriate, in the contract or in one of its appendices.

Apart from the question of whether adverse underground conditions could have been reasonably foreseen, there is the problem of what should be done when they are met with. It may be, for example, that the engineer will admit that the presence of rock in the course of certain tunnelling could not have been foreseen. The engineer may, however, take a different view from the contractor when deciding what amount, or kind, of extra work needs to be done to meet the situation. The engineer should bear this aspect of the matter in mind when deciding what form of notice he wants from the contractor should adverse circumstances be encountered. If the engineer knows in some detail at an early moment what steps the contractor is taking, he is in a position to agree or disagree at once and this may often save much argument at a later date. By the same token, the engineer will desire to know not only what steps are to be taken but also what delays are involved, since this information may affect his decision whether or not to make a variation order. Thus, problems underground can be very complex.

Whenever it is likely that such problems may arise, or, in the case of large-scale works, will arise, the engineer should consider what should go in the contract regarding the notices to be served. Probably the simplest way is for him to

draft the kind of notices he wishes to receive and to give. Such draft forms help the draftsman to draw up appropriate conditions and they may also be annexed to the contract as the forms of notice to be used.

SUMMARY

Arguments over conditions below ground are among the most vexed and difficult which arise from engineering contracts. Avoiding these arguments is mainly a matter of careful technical work, but the contract can be so drawn as to assist in eliminating or, at least, in diminishing such arguments. The contract documents should sometimes include the data which exists about the site, and what is, or is not, to be regarded as unexpected may often be linked to this data. The contractor will normally be responsible for anything unusual which he could reasonably have foreseen. What he could have so foreseen is usually a question of fact but the contract should not normally allow this to depend upon mere inspection of the site.

Where unexpected conditions are found, the function of the contract is to provide a procedure which will allow the work to proceed with the least difficulty or interference. The engineer may find it worthwhile to consider, at the time when the contract is drafted, what procedure he wishes to be followed and inform the draftsman accordingly. In doing this, he will find it useful to give particular attention to the form and content of any notices which he requires to be served, or given, in connection with unexpected conditions underground.

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PLASTICS COATINGS FOR METAL ARTICLES

An Immersion Process

A process for the production of corrosion-resisting and electrically-insulating plastic coatings and linings on metal articles has been made available by Horwitch Smith and Company Limited, Pensnett, Brierley Hill, Staffordshire. The Griesheim whirl sinter process, as it is called, is in effect a dipping process in which hot articles are held in a container filled with powdered plastics kept in motion, or " fluidised," by a stream of air or nitrogen.

The apparatus consists essentially of a powder container fitted with a lid, a sieve base and an air or nitrogen connection having a control valve; nitrogen is preferable to air as the former will prevent oxidation taking place. The sieve base is made of a ceramic material having fine pores; this is impermeable to the powder in the container but the upward flowing nitrogen penetrates the ceramic base without much loss of pressure and sets the overlying plastic powder in motion. The powder is given a circular movement and the gas pressure is adjusted by means of the control valve so that the powder is in continuous motion and in a state approximating to that of a liquid. Thus uniform coatings are imparted to articles even of complex shape.

The plastic materials used consist of specially-prepared polymers, comprising polyethylene and other resins, and additions may be made to enhance the adhesion of the coating. For covering large areas, additions of poly-iso-butylene are also made to enable the coatings to resist high stresses. The articles to be coated are degreased and are generally sand-blasted and are then heated to a temperature of from 220 to 250 deg. C. They are immediately immersed for from 30 to 50 seconds in the fluidised powder and should be kept in motion while in the container.

It is stated that an article made of material $\frac{3}{8}$ in. thick and heated to 250 deg. C., will acquire a coating $\frac{1}{32}$ in. in thickness in one immersion. Heating to 200 deg. C., will give a coating $\frac{1}{64}$ in. in thickness. When an article is taken out of the powder container, particles of the plastic polymer are seen on the surface, but after a few seconds these melt into the coating owing to the heat stored up in the metal. In the case of thin-walled articles, however, the heat remaining in the metal may not be sufficient to achieve this final melting. In such cases the article is treated in a soft gas flame for a few seconds or is baked in an oven for some 5 to 10 minutes at a temperature of 120–140 deg. C., until the coating is completely smooth.

Among the articles found suitable for coating and lining by the whirl sinter process are plating racks, anodising jigs, small exhaust fans, pump impellers and cases, sieves and sieve frames, various electrical components, buckets and small containers, lids, safety coverings, and sleeves and sleeve connections.

Two types of sinter apparatus are available, namely a cylindrical and a larger, rectangular, pattern. One example of the former type has a diameter of 20 in., a depth of $15\frac{1}{2}$ in. and a powder capacity of from 20 to 30 lb. One of the rectangular models measures 28 in. in length, 22 in. in width, 24 in. in depth and has a powder capacity of 70–90 lb.

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DE-IONISATION METHOD OF WATER PURIFICATION

Paterson Solobed Process

The discovery, some years ago, that certain synthetic resins possessed the ability to remove the bases and acid radicals from water by an exchange of ions brought about a new conception in water-treatment practice. Previously, the removal of the bases calcium and magnesium by replacing them with the element sodium had been accepted as standard practice in the base-exchange softening of water. It was ascertained, however, that if water were passed through a column of one of the synthetic resins in the hydrogen form, i.e., that capable of regeneration by acid, and then through a column of another resin in the hydroxyl form, i.e., that capable of regeneration by alkali, the resultant exchange removed not only the bases, calcium, magnesium and sodium, but the carbonic, sulphuric, hydrochloric and nitric acid radicals as well, thus producing a pure salt-free water without the necessity of distillation.

Owing to the somewhat high cost of manufacture and relatively low efficiency of the resins, the process remained in abeyance for some years, but, since 1945, great advances have been made in the production of the requisite resins.

In the Solobed system of de-ionisation developed by the Paterson Engineering Company, Limited, Windsor House, Kingsway, London, W.C.2, water of extremely high purity is obtained and since the use of fuel in any form is not involved, the production costs are generally well below those of distillation processes.

The two types of resins, in bead-shaped particles, are mixed and placed in one vessel. In the smallest unit this consists of a transparent plastic cylinder, with pipe work and valves made of polythene or ebonite. The tanks used for preparing the regenerating solutions are also made from a transparent plastics. There is thus no metal in contact with the water, an important matter with water of such high purity. In the larger installations, the cylinders are made of steel but they are lined with rubber or plastics material and windows are provided, through which the separation and re-mixing processes, described below, can be observed.

For controlling the rate of flow and testing the purity, the water is metered on entering the unit and an instrument at the outlet measures its resistance to an electric current. This, it appears, is the only satisfactory method of instantly determining the purity of the water, and the instrument can be pre-set to give audible or visual warning when the resins are becoming exhausted.

The resins are regenerated by means of dilute acid and alkali solutions. The flow of water in the apparatus is first reversed and, since one resin is lighter than the other, this has the effect of separating the two types. Dilute caustic soda is introduced at the top of the unit, runs through the upper resin and passes out at the interface. This resin is then rinsed with water running in the same direction to remove the excess alkali. Dilute hydrochloric, or sulphuric, acid is then introduced at the interface, runs through the lower resin and passes out at the base of the unit. The acid, in turn, is followed by rinsing water in the same direction. Finally, the resins, which mingle readily, are remixed by means of compressed air, introduced at the base of the cylinder.

Both the resins employed are stable over the full *p*H range and, for treating waters containing organic matter in solution, porous varieties of the resins are used. These are unaffected by the impurities, which are washed out during regeneration.

The Solobed de-ionisation process has been found of great value in providing water of very high purity for boilers, and for beverage production and chemical, electronic and pharmaceutical processes. It is also used in the manufacture of ice, cosmetics, television tubes and storage batteries and in the electroplating and photographic industries.

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CATALYST FOR ELIMINATING INDUSTRIAL FUMES

A Solution to Air Pollution

A new company, Oxy-Catalyst Sales Limited, Henley Park, Guildford, Surrey, a subsidiary company of Vokes Limited, has been formed to make available to British industry a catalytic product of the Oxy-Catalyst Company, termed Oxycat. The primary function of this is to eliminate the obnoxious portions of industrial exhaust fumes or waste gases containing combustible matter. The originator of the catalyst is Mr. E. J. Houdry (who is also responsible for a petroleum catalytic-cracking process) and it is claimed to have been in successful operation in the United States for a number of years.

The new material is stated to be an active and stable oxidation catalyst which causes or hastens the reaction of oxidation of carbon, hydrogen, and various combinations of these elements. The Oxycat apparatus consists of two end plates, a tie-rod and a number of streamlined elements coated with a film of " catalytic alumina " and an alloy of platinum. This film, which is strongly resistant to high temperatures and to thermal shock, is the agent which converts objectionable exhaust fumes containing hydrocarbons, and carbon particles in the form of black smoke, into oxides, generating heat in the course of the process.

When the concentration of combustible materials in the exhaust gases is high enough to result in an increase in temperature through the bed of the catalyst sufficient to justify the recovery or the utilisation of the heat generated, the system can be employed as a heat-recovery unit. After oxidation, the hot, clean air and gases can be recirculated, and where this is not practicable, the heat can be utilised to generate steam or hot water.

The installation of the catalyst is relatively simple. The units are arranged in a bed side by side, end to end, and stacked 2, 3 or 4 layers deep. Ceramic spacers are placed over and between the end plates to tie the units together into a rigid whole. To start the catalytic reaction, the gaseous stream entering the unit must be at a minimum temperature of 500 deg. F. Once started the reaction itself will increase the temperature of the catalyst until a state of equilibrium is reached. The normal procedure is to fit an automatically-controlled pre-heating burner ahead of the catalyst to assist in starting up. It is emphasised that one of the outstanding advantages of the Oxycat units is their " very long life."

BEHAVIOUR OF BUILT-UP GIRDERS UNDER TORSION

METHOD OF CALCULATING STRESSES AND DISTORTION

By J. S. Terrington, B.SC.(ENG.), A.M.I.C.E., A.M.I.STRUCT.E., A.C.G.I.*

One of the objectives of the study of lateral surge loads exerted by crane wheels on gantries is to establish a method of calculation of the resulting stresses more exactly than the empirical methods now in use. Following a study of the fundamental considerations[1-17 et alia] this article describes the complete stress conditions set up in a composite girder of asymmetrical section under crane-wheel loading and summarises, for general use, the equations which have already been developed by the author.[18, 21, 22, 23] This method is applicable to sections which comprise component girders with both solid webs and open lattice construction where flanges are separated by triangulated bracing or where simply held in position by spacing ties or struts. A typical girder of this nature is shown in Fig. 1. The validity of the method has already been confirmed by tests carried out on full-size grinders and on a model girder at B.I.S.R.A.'s laboratory.[19, 20, 24]

CONDITIONS AND THE PROBLEM

In structural design, most girder sections are symmetrical about the vertical axis and many of these are also symmetrical about the horizontal axis. In addition, the vertical and/or lateral loads may cause corresponding deflections, but twisting does not usually occur, because the loading and the section are symmetrically arranged with one another, as in Fig. 2*a*. In the case of crane-gantry girders, the attachment of the horizontal girder, and sometimes a vertical auxiliary girder, to resist lateral surge, or the thickening or widening of the compression flange, throws the section out of symmetry; and the lateral surge acting simultaneously with the vertical wheel load both tend to impose an eccentric load on the section as in Fig. 2*b*. The degree of eccentricity of the loading depends on the extent to which the resultant of the vertical and lateral loads is eccentric with a point in the cross-section of the girder known as the "centre of rotation," that is, the centre about which the section naturally twists. This "centre of rotation" has elsewhere[22, 23] been shown to be the "shear centre" of the composite section and the method of computing its location has been fully considered and explained in the articles referred to. In these articles, it is made clear that the centre of rotation or "shear centre" is not, by any means, necessarily at the centre of area of the section.

The product of the resultant load and the eccentricity of the resultant about the centre of rotation is a measure of the torque or twisting effect on the section. It also follows that if the resultant of the loading passes through the centre of rotation, then the section may bend about two axes but will not twist. The problem may, therefore, be separated into simple bending about two axes, usually the X-X and Y-Y (rectangular) axes with the loads transferred so that they pass through the centre of rotation, and a rotational moment M_z, about the centre of rotation. This treatment of separating the orthogonal and torsional moments is satisfactory for all practical purposes but it should be appreciated that, as shown in Appendix I, page 589, the bending moments and the ultimate angle of twist react on the final deflections and stresses and, in extreme cases, such as very slender beams, more refinement in determining the angle of twist may be desirable. When estimating the bending effect in symmetrical sections, the most usual case in practice, the calculation about the X-X and Y-Y axes is actually being made about the principal axes. In the case of the asymmetrical type of girder under consideration, however, due allowance has to be made for the fact that the principal axes are at some inclination to the rectangular X-X and Y-Y axes. Before evaluating the bending and torsional effects, three points need to be emphasised.

The first point is that the complete girder including main girder, surge girder, auxiliary girder or other component girders are regarded as comprising a complete wholly asymmetrical girder section and that although there may be some slight distortion or racking, this assumption has been largely justified by full-size tests. The section may therefore be composed of one or more girders as in Fig. 3 and each girder can comprise flanges and web plate or flanges and individual web members. The second point is that the method is applicable to all kinds of distribution of the loading along the girder; this aspect being of particular importance concerning the torsional effect. For brevity, and to simplify the issues, three principal forms of loading are considered here, namely:—

(i) a point load at mid-span,
(ii) two point loading, symmetrical about mid-span (corresponding to a pair of crane wheels), and
(iii) a uniform load (approximating to a number of wheels, such as those supporting two or more cranes, on the span.

The third point to emphasise is that every effort is made here to simplify the problems considered; a more complete analysis is given in the appendices.

Fig. 1 Main girders, cross members and ties all contribute by a combination of bending, twisting and direct tension or compression to the gross torsional and bending strength of a built-up girder.

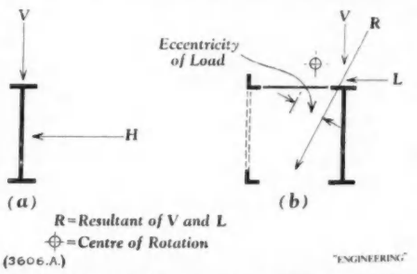

Fig. 2 The resisting torque of a built-up girder consists of combined effects of torsion and bending in each of the component members. The proportions of torsion and bending are determined by a consideration of the fundamental equations.

* Of the British Iron and Steel Research Association.

NOTATION

a = torsional bending constant,
b = width of flange or width of element of section,
B = torsional bending coefficient,
E = Young's modulus,
f = stress,
G = torsional modulus $= \frac{E}{2{\cdot}6}$
$I_x\ I_y\ I_z$ = moments of inertia of complete section about rectangular axes,
$I_{z_p}\ I_{y_p}\ I_{z_p}$ = moments of inertia of complete section about principal axes,
$I_1\ I_2$, etc. = moments of inertia of individual component girders,
J = torsion constant of section,
$K_1\ K_2$, etc. = distances of component girders from the centre of rotation of the section,
l = span,
L = lateral load,
$M_x\ M_y\ M_z$ = bending moments about rectangular axes,
$M_{z_p}\ M_{y_p}\ M_{z_p}$ = bending moments about principal axes,
r = minimum radius of gyration of section,
$S_1\ S_2$, etc. = shear induced in the respective component girders due to the torsion,
S = torsional shear coefficient,
t = thickness of element of section,
T_0 = torque,
V = vertical load,
$x\ y\ z$ = co-ordinates of a point on a section related to rectangular axes,
$x_p\ y_p\ z_p$ = co-ordinates of a point on a section related to principal axes,
X-X, Y-Y, Z-Z = rectangular axes before bending,
X_1-X_1, Y_1-Y_1, Z_1-Z_1 = rectangular axes after bending,
X_p-X_p, Y_p-Y_p, Z_p-Z_p = rectangular principal axes,
θ_p = angle principal axes make with rectangular axes,
ψ = angle of twist due to torsion (excluding the effects of bending),
ϕ = angle of twist due to torsion (including the effects of bending),
and $T_z = M_z$ = Torque.

FORMULAE

The method of calculation consists of evaluating the stresses which arise due to:—

(1) Bending and shear about the X-X and Y-Y axes of the composite section ignoring the torsional effect on the girder—this assumes that the reaction at the section passes through the shear centre or centre of rotation—and making due allowance for the fact that the principal axes, X_p-X_p and Y_p-Y_p, may not coincide with the rectangular axes. If the angle of twist

is appreciable, then the component of M_x acting along Y_p-Y_p may be added algebraically to M_y and the component of M_y acting along X_p-X_p may be added algebraically to M_x.

(2) The twisting or torsional moment, $M_{z'}$, i.e., the moment about the Z′-Z′ or longitudinal axis of the girder. Then adding the stresses from the torsional moment to those due to bending and shear about the X′-X′ and Y′-Y′ axes.

Considering the above operations (1) and (2) in more detail:—

(1) *Resistance to Bending and Shear* (*excluding torsional effects*).—Concerning the stresses which arise due to pure bending and shear about the X-X and Y-Y axes at any point on any cross-section of the girder, these are normal fibre stresses and shearing stresses which are calculated in the usual manner, knowing the distribution of the load along the girder. To allow for the fact that the principal axes X_p-X_p and Y_p-Y_p may not coincide with the rectangular axes X-X and Y-Y, it is necessary to know:—

(*a*) the inclination, θ_p, of the principal axes relative to the rectangular axes;

(*b*) the co-ordinates (x_p y_p) of any point on the cross-section at which the stress is required relative to the principal axes; and

(*c*) the magnitude of the moments of inertia, I_{x_p} I_{y_p} of the section about the principal axes.

Having calculated the values of the quantities x, y, I_x, I_y, I_{xy} about the rectangular axes X-X and Y-Y, the above quantities are given by the equations:—

$$(a)\quad \tan 2\theta_p = \frac{2\,I_{xy}}{I_y - I_x}$$

$$(b)\quad x_p = y\cos\theta_p - x\sin\theta_p$$
$$y_p = y\sin\theta_p + x\cos\theta_p$$

$$(c)\quad I_{x_p} + I_{y_p} = I_x + I_y$$
$$I_{x_p} - I_{y_p} = (I_x - I_y)\cos 2\theta_p - 2\,I_{xy}\sin 2\theta_p$$

From these equations, the bending and shearing stresses can be calculated.

(2) *Resistance to Twisting or Torsional Effects.*—Concerning the stresses which arise due to the twisting or torsional moment at any point on any cross-section of the girder, these are due to two effects:

(*a*) purely torsional stresses, and

(*b*) bending and shear stresses (in addition to those due to flexure without torsion) developed, for the most part, in the "flanges" of the section, since they bend separately as individual beams or girders. (The "flanges" may be actual flanges as in an R.S.J., or component girders, as in a composite gantry girder.)

The magnitude of the total external twisting or torsional moment imposed on any cross-section of the girder depends on:—

(i) the distribution of the eccentric load along the length of the girder which determines the shearing force and the bending moment in the "flanges" (as a result of the torsion) at the section considered; and

(ii) the eccentricity of the resultant shearing force on the section relative to the shear centre or centre of rotation. This is, of course, determined by the position of the vertical and horizontal components of the load (e.g., a wheel load) in relation to the transverse section.

The torsional resistance of the section afforded by purely torsional stresses is well known to be proportional to the torsional rigidity GJ and to the angle of twist per unit length, $\frac{d\psi}{dz}$; where G is the modulus of torsion of the material $\left(\frac{E}{2{\cdot}6}\text{ approximately for steel}\right)$ and J is the torsional constant of the section. J is approximately equal to $\frac{1{\cdot}26}{3}\times$ the sum of all the products of the widths, b, and their thicknesses, t, or $J = \frac{1{\cdot}26}{3}\times \Sigma\, b\, t^3$. Hence this part of the torsional resistance is $G\,J\frac{d\psi}{dz}$.

Also, the torsional resistance of the section afforded by purely bending and shearing stresses due to flexure of each of the "flanges" of the section separately, is the sum of the products of the respective shears, S_1, S_2, S_3, etc., developed by the flexure in each of the flanges and the distances K_1, K_2, K_3, etc., of each flange from the centre of rotation, i.e., $S_1K_1 + S_2K_2 + S_3K_3$, etc. The magnitude of each of the shears S_1, S_2, S_3, etc., is shown in Appendix I to be equal to the products $E\,I_1\,K_1\frac{d^3\psi}{dz^3}$, $E\,I_2\,K_2\frac{d^3\psi}{dz^3}$, $E\,I_3\,K_3\frac{d^3\psi}{dz^3}$, etc. Hence the proportion of the torsional resistance of the section afforded by purely bending and shearing stresses is $E\,\Sigma\,I_1K_1^2\frac{d^3\psi}{dz^3}$.

It will therefore be seen that the total resistance of the section due to the two effects is

$M_{z'}$ = pure torsional resistance + flexural resistance of flanges

or

$$T_o = T' + T'' \quad \text{(see Appendix II and Fig. 4)}$$
$$= G\,J\frac{d\psi}{dz} - E\,\Sigma\,I_1K_1^2\frac{d^3\psi}{dz^3}$$
$$= G\,J\frac{d\psi}{dz} - a^2\,G\,J\frac{d^3\psi}{dz^3}$$

where

$$a^2 = \frac{E}{G\,J}\,\Sigma\,I_1K_1^2.$$

The analysis, which is summarised in Appendix II and evaluated in Fig. 4, shows that these functions of the angle of twist ψ are dependent on the ratio of the half span, $\frac{l}{2}$, to the factor a, i.e., to $\frac{l}{2a}$. This is somewhat analogous to the slenderness ratio of a slender strut which, it will be remembered, depends on the ratio of the length, l, to the radius of gyration, r, i.e., to $\frac{l}{r}$. The functions of the angle of twist are also dependent on the form of the distribution of the load along the girder, because the distribution of the load affects the torque and hence the angle of twist ψ.

It will be observed that the factor a is more complex than the radius of gyration and is, in fact, a ratio of the torsional resistance due to flexure of the flanges acting about a centre of rotation, to the purely torsional rigidity of the section.

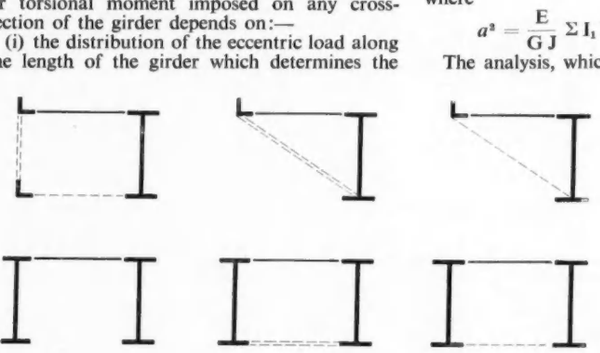

Fig. 3 Typical sections of the type amenable to the calculation method proposed in the article. The method is applicable to any form of load distribution along the girder; this is of particular importance in the consideration of torsional effects.

— Solid Plate
= = = Triangulated Cross Bracing
– – – Un-Triangulated Struts or Ties at Intervals

(3606 c.)

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Torsional Distribution in Relation to Loading Distribution

The effect of the loading—when the torque is exerted—and hence the torsional distribution along the girder is shown in Fig. 4 for three cardinal types of load or torque distribution, namely:—

(*a*) at the mid-point of the span,

(*b*) at two points symmetrical about mid-span, and

(*c*) uniformly along the length of the span,

corresponding to (*a*) an eccentric point load at mid-span (*b*) two eccentric point loads symmetrical about mid-span and (*c*) an eccentric uniform load.

Although the angle of twist ϕ and the bending of the girder affects the total torque on the girder it may be taken as correct for practical purposes that the distribution of constant torque is the torque due to a point load at mid-span arranged eccentrically to the shear centre, that the distribution of constant torque over the ends of the girder is the torque due to two point loads, and that the distribution of the torque which varies linearly from the supports to mid-span is the torque due to a uniform load arranged eccentrically with respect to the shear centre. In theory, and particularly if the girder is slender, such that I_x and I_y are radically different in magnitude, or more generally, the factor a is small compared with l, the resulting torque is increased due to the angle of twist. This may, however, in many practical cases be regarded as a secondary effect.

Mode of Resistance to Torsion

As has already been shown, the girder resists the torsional moment, $M_{z'}$, partly by pure torsion of the section and partly by flexure of the flanges and from Fig. 4 it will be seen that the smaller the factor $\frac{l}{2a}$ is, the larger the proportion of the torque is taken by flexure of the flanges. Now, $\frac{l}{2a}$ can be large by virtue of a long span (and vice versa) or by the factor a being small in itself. This leads to an appreciation of the factor a because, in a section formed of light flanges laced far apart, the value of $\Sigma\,I_1K_1^2$ will be large compared with G J; a will then be large and hence for a given span l the factor $\frac{l}{2a}$ will be low and, as shown in Fig. 4, most of the torque will be resisted by flexure in the flanges.

Conversely if a section is small and concentrated, the value of G J will be larger than $\Sigma\,I_1K_1^2$ whence a will be small and, for a given span l the factor $\frac{l}{2a}$ will be large and, as shown in Fig. 4, most of the torque will be resisted by purely torsional stresses.

It can be seen from Fig. 4 that in the case of an eccentric point load all the resistance at mid-span is provided by flexure of the flanges. At the support, the resistance will be provided

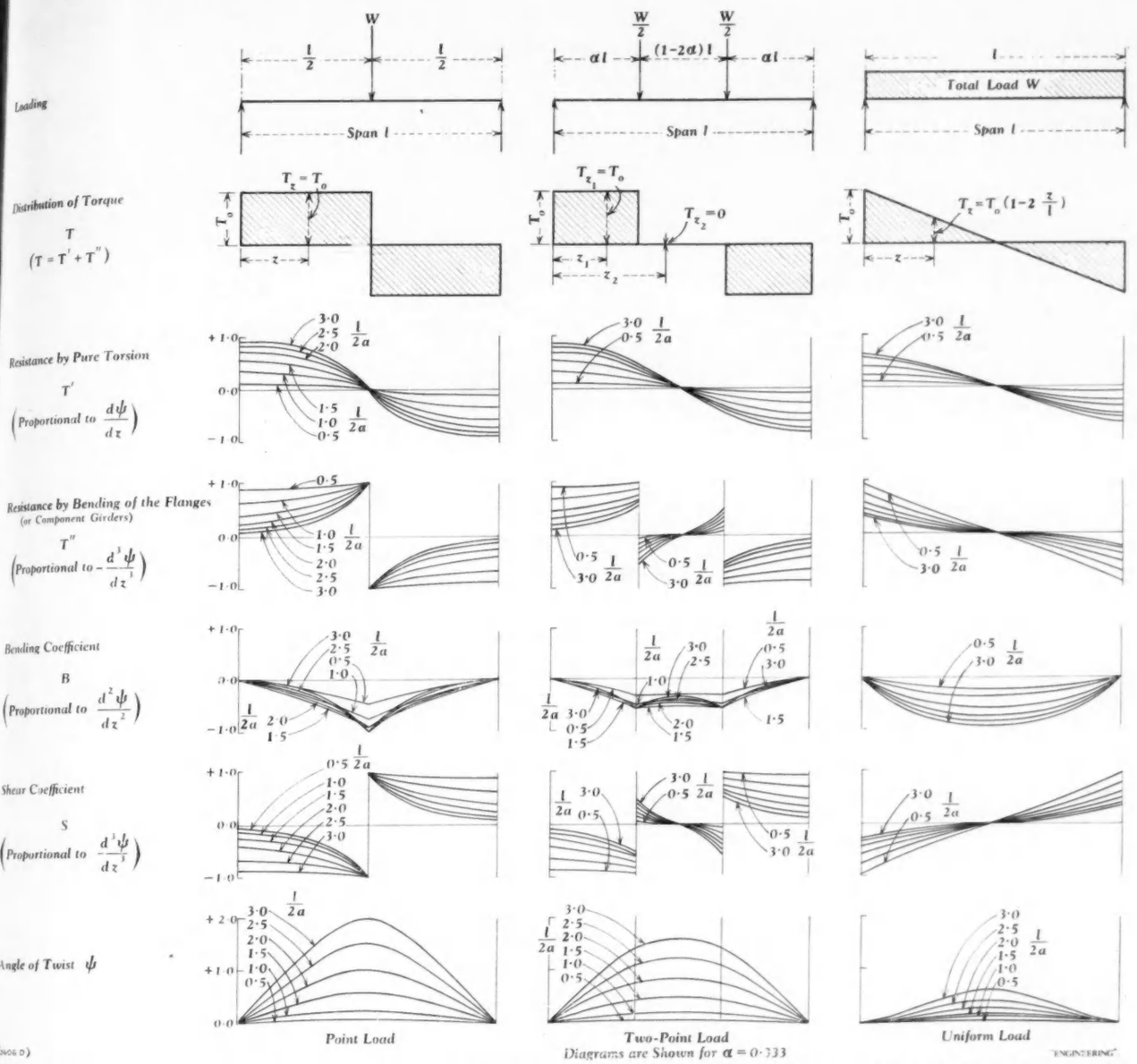

Fig. 4 The shear (by torsion) and bending coefficients for three standard forms of beam loading, showing the proportions of the total torque that are resisted by pure torsion and by bending in the component members of the girder. The bottom diagram shows the variation in the angle of twist along the beam.

largely by pure torsion, if the girder is long (i.e., $\frac{l}{2a}$ is large) but by flexure of the flanges if the girder is short (i.e., $\frac{l}{2a}$ is small). In the case of an eccentric uniform load, there is no torsion at all at mid-span but the torsion increases to a maximum at the supports, again being resisted by pure torsion if the girder is long (i.e., $\frac{l}{2a}$ is large) and by flexure of the flanges if the girder is short (i.e., $\frac{l}{2a}$ is small). There are, of course, gradations between these two conditions for intermediate values of the span l or the factor a and also in the case of other intermediate types of loading. These three cardinal types of loading can, however, be adapted sufficiently for general use.

A corollary to this discussion emerges, and that is, for a given span l, if it is desired to limit the angle of twist, it is essential that $\frac{l}{2a}$ should be as small as possible, in which case the torque will be resisted largely by flexure of the flanges. The factor a should therefore be large, i.e., $\Sigma I_1 K_1^2$ should be large compared with G J. This means that open-lattice type of component girders, would, in such a case as this, be the more preferable.

Angle of Twist

The angle of twist at any cross-section, like the torque, is actually increased by both the torque and the bending but for practical purposes can be taken as if there were torsion only, and values for the three loading conditions considered are shown in Fig. 4. The value of the angle of twist is only needed when it is sufficiently large to affect the stresses.

Application to Design

Copies of this article with copies of examples extracted from two of the papers[19, 21] mentioned in the bibliography to this article, with additional notes, are available from the Information Officer, the British Iron and Steel Research Association, 11 Park-lane, London, W.1.

APPENDIX I

General Equations of Stability (including Value of Factor *a*)

The complete equations for bending and torsion involve a consideration of the three axes X-X, Y-Y, and Z-Z (the latter being the axis of the girder), see Fig. 5, page 590. The axes after bending and torion are X'-X', Y'-Y' and Z'-Z'; and the equations are:—

$$M_{x'} = + E I_x \frac{d^2v}{dz^2} = - M_x + M_y\phi + M_z \frac{du}{dz}$$

$$M_{y'} = + E I_y \frac{d^2u}{dz^2} = - M_x\phi - M_y - M_z \frac{dv}{dz}$$

$$M_{z'} = G J \frac{d\phi}{dz} - a^2 G J \frac{d^3\phi}{dz^3} = + M_x \frac{du}{dz} - M_y \frac{dv}{dz} + M_z$$

$$= G J \frac{d\phi}{dz} - E \Sigma I_1 K_1^2 \frac{d^3\phi}{dz^3}$$

whence $a^2 = \frac{E}{G J} \Sigma I_1 K_1^2$.

APPENDIX II

Derivation of Formulae for Three Conditions of Loading

(i) *Point Load.* $T_z = T_0$ = constant when $z=0 \rightarrow l$.

(ii) *Two-Point Load.* $T_z = T_0$ = constant when $z = 0 \rightarrow \alpha l$ and $(1-\alpha) l \rightarrow l$ and $T_z = 0$ when $z = a l \rightarrow (1-\alpha) l$.

(iii) *Uniform Load.* $T_z = T_0\left(1 - \frac{2z}{l}\right)$.

The torque at any point Z along the girder is T_z and

T_z = Resistance due to pure torsion + Resistance due to flexure of flanges

$$= G J \frac{d\psi}{dz} - a^2 G J \frac{d^3\psi}{dz^3}$$

and solutions are:—

Point Load

$$\psi = A_1 \sinh \frac{z}{a} + B_1 \cosh \frac{z}{a} + C_1 + \frac{T_0}{2 G J} l\left(\frac{2z}{l}\right) \quad . \quad (1)$$

Two-Point Load

$$\psi = A_2 \sinh \frac{z}{a} + B_2 \cosh \frac{z}{a} + C_2 + \frac{T_0}{G J} \alpha l\left(\frac{z}{a l}\right). \quad (2)$$

for $z = 0 \rightarrow \alpha l$ and

$$= A_3 \sinh \frac{z}{a} + B_3 \cosh \frac{z}{a} + C_3 + \frac{T_0}{G J} \alpha l \quad (3)$$

for $z = \alpha l \rightarrow (1 - \alpha) l$

Uniform Load

$$\psi = A_4 \sinh \frac{z}{a} + B_4 \cosh \frac{z}{a} + C_4 + \frac{T_0}{2 G J} l\left[\left(\frac{2z}{l}\right) - \frac{1}{2}\left(\frac{2z}{l}\right)^2\right] \quad . \quad (4)$$

Applying the relationships :—when $z = 0$,

$$\psi = 0 \text{ and } \frac{d^2\psi}{dz^2} = 0$$

when $z = \alpha l$,

ψ from equation (2) = ψ from equation (3)

and $\frac{d\psi}{dz}$ from equation (2) = $\frac{d\psi}{dz}$ from equation (3)

and $\frac{d^2\psi}{dz^2}$ from equation (2) = $\frac{d^2\psi}{dz^2}$ from equation (3)

when $z = \frac{l}{2}$, $\frac{d\psi}{dz} = 0$

then the following equations result:—

Point Load

$$\psi = \frac{T_0}{G J} a\left[-\frac{\sinh \frac{z}{a}}{\cosh \frac{l}{2a}} + \frac{l}{2a}\left(\frac{2z}{l}\right)\right]$$

$$\frac{d\psi}{dz} = \frac{T_0}{G J}\left[-\frac{\cosh \frac{z}{a}}{\cosh \frac{l}{2a}} + 1\right]$$

$$\frac{d^2\psi}{dz^2} = \frac{T_0}{G J}\frac{1}{a}\left[-\frac{\sinh \frac{z}{a}}{\cosh \frac{l}{2a}}\right]$$

$$\frac{d^3\psi}{dz^3} = \frac{T_0}{G J}\frac{1}{a^2}\left[-\frac{\cosh \frac{z}{a}}{\cosh \frac{l}{2a}}\right]$$

Two-Point Load

$$\psi = \frac{T_0}{G J} a\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\sinh \frac{z}{a} + \frac{z}{a}\right]$$

where $z = 0 \rightarrow \alpha l$

$$= \frac{T_0}{G J} a\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\sinh \frac{z}{a} + \cosh \frac{z}{a}\right) + \frac{\alpha l}{a}\right]$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$\frac{d\psi}{dz} = \frac{T_0}{G J}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\cosh \frac{z}{a} + 1\right]$$

where $z = 0 \rightarrow \alpha l$

$$= \frac{T_0}{G J}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right]$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$\frac{d^2\psi}{dz^2} = \frac{T_0}{G J}\frac{1}{a}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\sinh \frac{z}{a}\right]$$

where $z = 0 \rightarrow \alpha l$

$$= \frac{T_0}{G J}\frac{1}{a}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\sinh \frac{z}{a} + \cosh \frac{z}{a}\right)\right]$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$\frac{d^3\psi}{dz^3} = \frac{T_0}{G J}\frac{1}{a^2}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\cosh \frac{z}{a}\right]$$

where $z = 0 \rightarrow \alpha l$

$$= \frac{T_0}{G J}\frac{1}{a^2}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right]$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

Uniform Load

$$\psi = \frac{T_0}{G J} a\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\sinh \frac{z}{a} + \cosh \frac{z}{a} - 1\right) + \frac{l}{2a}\left(\frac{2z}{l}\frac{1}{2}\left(\frac{2z}{l}\right)^2\right)\right]$$

$$\frac{d\psi}{dz} = \frac{T_0}{G J}\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right) + \frac{l}{2}\left(\frac{2}{l} - \frac{4z}{l}\right)\right]$$

$$\frac{d^2\psi}{dz^2} = \frac{T_0}{G J}\frac{1}{a}\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\sinh \frac{z}{a} + \cosh \frac{z}{a}\right) - \frac{2a}{l}\right]$$

$$\frac{d^3\psi}{dz^3} = \frac{T_0}{G J}\frac{1}{a^2}\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right]$$

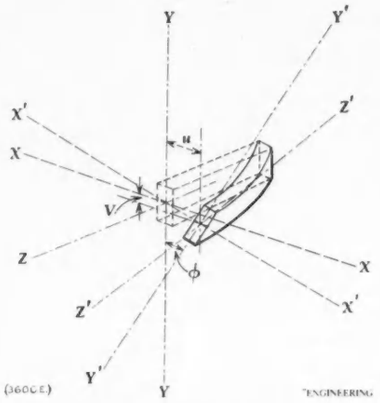

Fig. 5 Axes of a beam before and under loading, showing the displacements and angle of twist.

From the above differentials, the shears and moments in the component girders, shown below, are obtained.

Girder Shears

Point Load

$$= E I_1 K_1 \frac{d^3\psi}{dz^3}$$

$$= E I_1 K_1 \frac{T_0}{G J}\frac{1}{a^2}\left[-\frac{\cosh \frac{z}{a}}{\cosh \frac{l}{2a}}\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0\left[-\frac{\cosh \frac{z}{a}}{\cosh \frac{l}{2a}}\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 S_p^* \text{ etc.}$$

Two-Point Load

$$= E I_1 K_1 \frac{d^3\psi}{dz^3}$$

$$= E I_1 K_1 \frac{T_0}{G J}\frac{1}{a^2}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\cosh \frac{z}{a}\right] \text{ etc.}$$

where $z = 0 \rightarrow \alpha l$,

$$= E I_1 K_1 \frac{T_0}{G J}\frac{1}{a^2}\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right] \text{ etc.}$$

where $z = \alpha l \rightarrow (1 - \alpha) l$,

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a} + \coth \frac{\alpha l}{a}\right)\cosh \frac{z}{a}\right] \text{ etc.}$$

where $z = 0 \rightarrow \alpha l$,

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0\left[-\sinh \frac{\alpha l}{a}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right] \text{ etc.}$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 S_{2p}^* \text{ etc.}$$

Uniform Load

$$= E I_1 K_1 \frac{d^3\psi}{dz^3}$$

$$= E I_1 K_1 \frac{T_0}{G J}\frac{1}{a^2}\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0\left[\frac{2a}{l}\left(-\tanh \frac{l}{2a}\cosh \frac{z}{a} + \sinh \frac{z}{a}\right)\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 S_u^* \text{ etc.}$$

Girder Bending Moments

Point Load

$$= E I_1 K_1 \frac{d^2\psi}{dz^2}$$

$$= E I_1 K_1 \frac{T_0}{G J}\frac{1}{a}\left[-\frac{\sinh \frac{z}{a}}{\cosh \frac{l}{2a}}\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I K^2} T_0 a\left[-\frac{\sinh \frac{z}{a}}{\cosh \frac{l}{2a}}\right] \text{ etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 a B_p^*, \text{ etc.}$$

* Values of these factors are plotted in Fig. 4.

Two-Point Load

$$= E_1 I_1 K_1 \frac{d^3\psi}{dz^3}$$

$$= E I_1 K_1 \frac{T_0}{G J} \frac{1}{a} \left[- \sinh \frac{\alpha l}{a} \left(- \tanh \frac{l}{2a} + \coth \frac{\alpha l}{a} \right) \sinh \frac{z}{a} \right] \text{etc.}$$

where $z = 0 \rightarrow \alpha l$

$$= E I_1 K_1 \frac{T_0}{G J} \frac{1}{a} \left[- \sinh \frac{\alpha l}{a} \left(- \tanh \frac{l}{2a} \sinh \frac{z}{a} + \cosh \frac{z}{a} \right) \right] \text{etc.}$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 a \left[- \sinh \frac{\alpha l}{a} \left(- \tanh \frac{l}{2a} + \coth \frac{\alpha l}{a} \right) \sinh \frac{z}{a} \right] \text{etc.}$$

where $z = 0 \rightarrow \alpha l$

$$= \frac{I_1 K_1}{I_1 K_1^2} T_0 a \left[- \sinh \frac{\alpha l}{a} \left(- \tanh \frac{l}{2a} \sinh \frac{z}{a} + \cosh \frac{z}{a} \right) \right] \text{etc.}$$

where $z = \alpha l \rightarrow (1 - \alpha) l$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 a B_{2p}^*, \text{ etc.}$$

Uniform Load

$$= E I_1 K_1 \frac{d^3\psi}{dz^3}$$

$$= E I_1 K_1 \frac{T_0}{G J} \frac{1}{a} \left[\frac{2a}{l} \left(- \tanh \frac{l}{2a} \sinh \frac{z}{a} + \cosh \frac{z}{a} \right) \right] \text{etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1} T_0 a \left[\frac{2a}{l} \left(- \tanh \frac{l}{2a} \sinh \frac{z}{a} + \cosh \frac{z}{a} \right) \right] \text{etc.}$$

$$= \frac{I_1 K_1}{\Sigma I_1 K_1^2} T_0 a B_u^*, \text{ etc.}$$

* Values of these factors are plotted in Fig. 4.

REFERENCES

[1] L. Prandtl, *Kipperscheinungen*, Thesis, München 1899).

[2] A. G. M. Michell, "Elastic Stability of Long Beams under Transverse Forces," *Phil. Mag.*, vol. 48 pages 298-309 (1899).

[3] R. Maillart, "Schnubmittelpunkt," *Schweiz Banz.*, vol. 77 page 195 (1921).

[4] J. Prescott, *Applied Elasticity*, page 499 (London: Longmans, Green & Co. (1924)).

[5] C. Weber, "Ubertragung des Drehmomentes in Balken mit doppel flanischigem Querschnitt," *Zeitschrift für Angewandte Math und Mech.* (1926).

[6] F. B. Seely, W. J. Putnam and W. L. Schwalbe, *The Torsional Effect of Transverse Bending Loads on Channel Beams*, Bulletin No. 211, University of Illinois, Urbana (1930).

[7] F. Stüssi, "Exzentrisches Kippen," *Schweiz Banz.*, vol. 105 no. 11, pages 123-125 (1935).

[8] S. Timoshenko, *Theory of Elastic Stability* (New York and London: McGraw-Hill Publishing Co. Ltd. (1936)).

[9] P. Kuhn, Technical Note No. 691, National Advisory Committee for Aeronautics.

[10] C. O. Dohrenwend, "Action of Deep Beams under Combined Vertical, Lateral and Torsional Loads," *Journal of Applied Mechanics* (1941).

[11] F. Meissner, *Beiträge zu Kipp-Problem gerader Träger mit Konstantem Guerschnitt*, Thesis, Brünn (1944).

[12] Karl de Vries, "Strength of Beams as Determined by Lateral Buckling," *Trans. Am. Soc. C.E.*, vol. 112 pages 1245-1271 (1947).

[13] W. F. Cassie and W. B. Dobie, "The Torsional Stiffness of Structural Sections," *The Structural Engineer*, vol. 26 page 154 (1948).

[14] A. R. Flint, "The Stability and Strength of Slender Beams," ENGINEERING, vol. 170 page 545 (1950) (*et alia*).

[15] B. Sourochnikoff, "Strength of I-Beams in Combined Bending and Torsion," *Trans. Am. Soc. C.E.*, vol. 75 (1950).

[16] O. Pettersson, *Combined Bending and Torsion of I-Beams of a Mono-Symmetrical Cross-Section*, Bulletin No. 10, Division of Building Studies and Structural Engineering, Stockholm, Sweden (1951).

[17] S. Timoshenko, *Collected Papers*, page 559 *et seq.* (New York and London: McGraw-Hill Publishing Co. Ltd.)

[18] J. S. Terrington, "The Distribution of Stress in Bisymmetrical Girders when Subjected to Combined Bending and Torsion," B.I.S.R.A. Paper PE/E/31/53.

[19] J. S. Terrington, "Tests on a Bisymmetrical Girder when Subjected to Combined Bending and Torsion," B.I.S.R.A. Paper PE/E/71/53.

[20] J. S. Terrington, "Combined Bending and Torsion Tests on a Bi-Symmetrical Girder," *Civil Engineering*, vol. 50 page 401 (April, 1955).

[21] J. S. Terrington, "The Distribution of Stress in Bi-Symmetrical Girders when Subjected to Combined Bending and Torsion," *Civil Engineering*, vol. 50 No. 594 (1955).

[22] J. S. Terrington, "The Determination of the Shear Centre in Asymmetrical Girders," B.I.S.R.A. Paper PE/E/34/54.

[23] J. S. Terrington, "The Torsion Centre of Girders," ENGINEERING, vol. 178 page 668 (1954).

[24] J. S. Terrington, "Tests on a 50 ft. Span Crane-Gantry Girder," B.I.S.R.A. Paper PE/E/15/55.

[25] A. N. Lowan, *Tables of Circular and Hyperbolic Sines and Cosines*, National Bureau of Standards, New York (1939).

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HIGH ENERGY SPARK IGNITION

The Use of Semi-Conductor Units

The present trend in heating and other installations using oil firing is to employ higher viscosity oils for economical reasons. It has, however, been found that oils with a viscosity exceeding 1,000 seconds Redwood cannot be ignited by the spark from a normal ignition transformer with an output of 23 milli-amperes at 10 kV.

Foster Transformers Limited, South Wimbledon, London, S.W.19, have therefore developed two high-energy units, which are illustrated below. These have maximum outputs of 1 and 8 joules respectively, the energy at the spark being 50 per cent. or more of these values. The one joule model should therefore be capable of igniting 1,000 seconds Redwood viscosity oil and the larger model oils with viscosities of from 4,000 to 10,000 seconds.

The spark plug used in these igniters is one that has been primarily developed for the ignition of atomised fuel in combustion chambers of gas-turbines, where not only the gas pressure but the altitude and temperature vary widely. The plug electrodes consist of a rod and cylinder, which are concentrically mounted and are insulated from each other. The ends of the electrodes and the insulation are flush and the insulation at this point carries a surface coating of semi-conducting material.

When a voltage is applied to the electrodes a current flows in the semi-conductor and, since the material is not homogeneous, tends to concentrate into a channel of minimum resistance. This channel heats up so that the current increases and there is a still further rise in temperature. This cumulative action causes a filament to be formed, the temperature of which is high enough to cause thermal ionisation, so that an arc occurs between the electrodes. This action may take as little as a microsecond, depending on the initial voltage applied.

A further advantage of this type of spark is that its formation is not prevented by the corrosion of the electrode since it occurs within the semi-conductor. In fact, the surface can be coated with thick oil without reducing the performance. As the voltage required is only 2 kV there is a saving in the cabling required in comparison with normal high-voltage practice, and both the corona and surface leakage are reduced.

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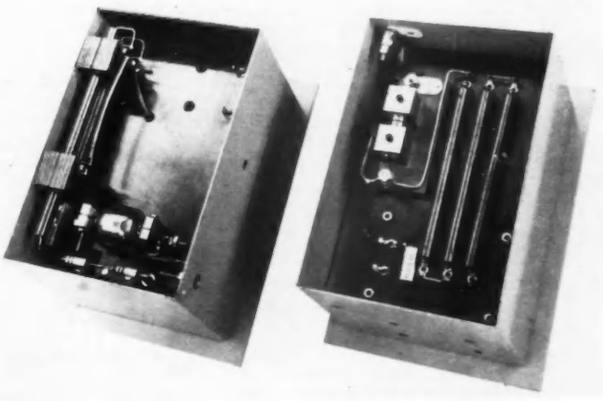
TRADE IN THE PLASTICS INDUSTRY

General Expansion Continues

It might have been expected that the credit squeeze, with the pressure it has generated on the market for consumer durable goods, would have caused a serious if temporary setback to the plastics industry. To judge from the net sales of plastics materials in the first six months of this year this has not happened. Just over 168,000 tons of plastics were sold between January and June compared with almost 162,000 tons in the same period of 1955. This was equal to an increase of 4 per cent. It seems to have been due to good export business, however, that nothing worse has happened than a significant slow-down in the rate of expansion. The main changes have been a decline in the sales of phenolic and cresylic plastics, but those of alkyd resins have increased by 10 per cent. owing to increased activity in the paint trade. Also in the thermo-setting group, production of polyesters has increased rapidly.

Most interest at the moment, however, centres on the thermo-plastic group where plans for the expansion of polyethylene plastics have recently been put in hand with the termination of I.C.I. patents. Last year the production of thermo-plastics passed that of thermo-setting materials for the first time and this change has gone slightly further in the first half of 1956. The sale of polyvinyl chlorides was down 5 per cent. compared with the first half of 1955, due to the fall in motor-car output, but this fall and a similar decline in the sale of cellulose plastics was more than offset by a rapid increase in sales of polythene.

Apart from comparatively short-term changes in the trade outlook, the plastics industry looks forward to a substantial increase in sales over the next few years. Total output in 1955 was 324,000 tons and the trade looks forward to achieving a target of 500,000 tons a year by 1960. Plastics manufacturers would seem to be more concerned with this target than the short-term difficulties due to the credit squeeze. None of the plant extensions recently planned has been cancelled in recent months and the industry continues to operate under the stimulus of more competitive trading in polythene and the development of synthetic rubber in the high-polymer group, where I.C.I. are developing a range of co-polymers of butadiene parallel with, but not dependent upon, the development of the synthetic rubber industry.



Electrical ignition units for high-viscosity oils.

PLATE BENDING BY ROLLING

USES OF VARIOUS TYPES OF MACHINE

By E. L. Tinley, M.I.MECH.E., F.INST.F.*

The problems of bending metal plate are summarised under four main headings and this study seeks to show the various forms in which designs of roller bending machines have been developed in order to meet the varied, and in some cases specialised, requirements of the plate-fabricating industry.

Firstly, there is the need to bend not only cylindrical vessels of normal diameter, range and length, such as tanks, boilers and pressure vessels, but also cylinders or pipes of small diameter and long length in the maximum thickness of plate possible; for example ships' masts and small-diameter gas, water and oil pipelines. In addition the need to bend conical shapes, rings for fabricated gearing and unbalanced sections, such as "lobster backs," has also to be catered for.

Secondly, the reduction of the work time-cycle to a minimum, by a reduction in the number of working passes per unit, simplification of setting the roll positions and the speed or convenience of entering the plate and withdrawing the work at the end of the operation.

Thirdly, the importance of bending the plate without, or with the minimum of, "barrelling" along the joint of the completed cylinder.

Fourthly, it is necessary to curve the plate to the finished radius as closely to each edge as possible, or provide some means, either in the machine or elsewhere, by which this can be achieved with the minimum amount of extra handling or operating cost.

* Technical Director, Joshua Bigwood and Son, Limited, Wolverhampton.

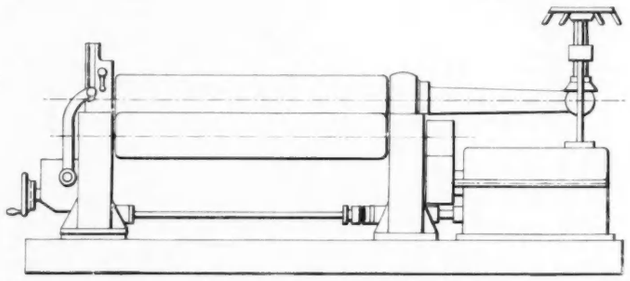
Such considerations as these must be flanked by others of importance, influencing the choice of the prospective user for the most suitable machine for this work. Factors such as the primary cost of the machine, versatility required, degree of skilled labour available, shop floor-space, shop height and crane facilities available all play a part in the selection of the most suitable machine.

Plate-rolls may be divided into two main groups. These are determined by the axes of the rolls or the disposition of the plate during the rolling operation namely:

(*a*) Horizontal rolls, in which the curvature is about a horizontal axis (Fig. 1) and

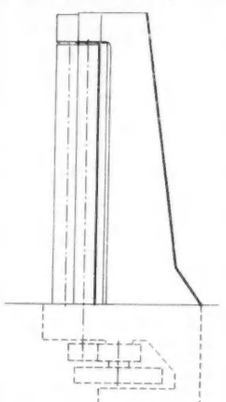
(*b*) Vertical type machines in which, as will be seen in Fig. 2, the roll-axes are disposed vertically,

For various reasons given later, by far the greater majority of plate rolls installed at the present time are of the horizontal type. Horizontal rolls may, in their turn, be subdivided into two further groups—pyramid and pinch types (the latter are sometimes referred to as "unilateral" or "initial-pinch"). In addition, however, a number of special or unconventional machines are employed for bending operations where special problems arise; these include shipyard rolls with beam-supported top roll, flexing top and flexing bottom roll benders for extra-long, small-diameter pipe work ("banana rolls"), the Baldwin-rolls for heavy stator frames and the hydraulic vertical roll-press for special-duty pressure-vessels.



(3813.A)

Fig. 1 Horizontal plate rolls.



(3813.A) "ENGINEERING"

Fig. 2 Vertical plate rolls.

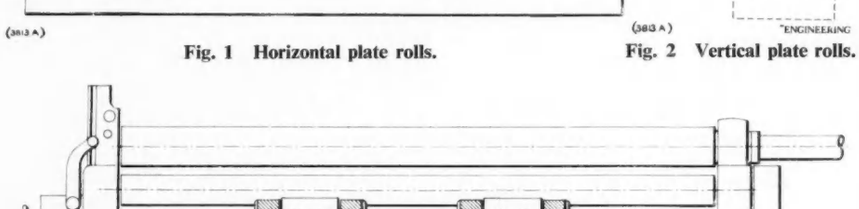


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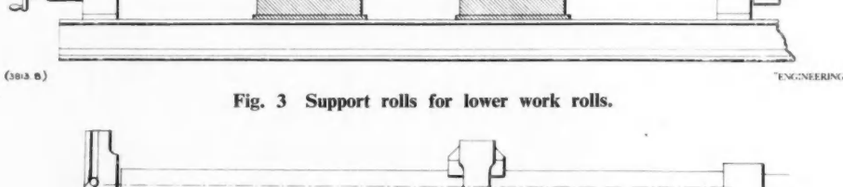
Fig. 3 Support rolls for lower work rolls.



(3813.C)

Fig. 4 Travelling roll support unit.

COMPARISON OF VERTICAL AND HORIZONTAL BENDING

The advantages of the vertically-disposed machine are:

(1) The plate is self-supporting on floor-plates or rollers during bending, thereby obviating the need for the crane for large diameter work.

(2) A small amount of floor-space is taken by the machine during non-working periods, the drive customarily being mounted below floor level.

(3) It is easier to ensure that the plate enters squarely into the rolls and less care in initial line-up of the plate is required, resting vertically as it does on the floor plates.

Disadvantages lie in:—

(1) The need either to lift out the bending-roll or alternatively to withdraw closed-cylinder work vertically, requiring a high shop and high crane rails.

(2) All vessels are bent, irrespective of length, about the lower end of the rolls, and, when rolling cylinders less than the full length of the rolls, unbalanced flexure of the bending roll introduces a tendency to taper the cylinder, except in the special case of beam supported vertical-roll machines.

(3) The frictional resistance of the floor, even when rollers are used, tends to cause inaccurate curvature when bending light gauge plate to large diameters.

(4) It is normally necessary to re-orientate the axis of the completed vessel to the horizontal when transferring to the welding table, which causes extra handling.

(5) Vertical rolls introduce serious handling difficulties when rolling cones.

HORIZONTAL ROLLS

Horizontally-disposed bending machines occupy more shop space when not in use, because of the area which must be left clear on both sides of the machine, but not greatly more so than vertical machines, and for large or heavy plate, supporting means by a crane at the start of working and while rolling to large diameters must be provided. Clear space must also be left at the draw-off end of the machine to allow for the withdrawal of completed cylinders.

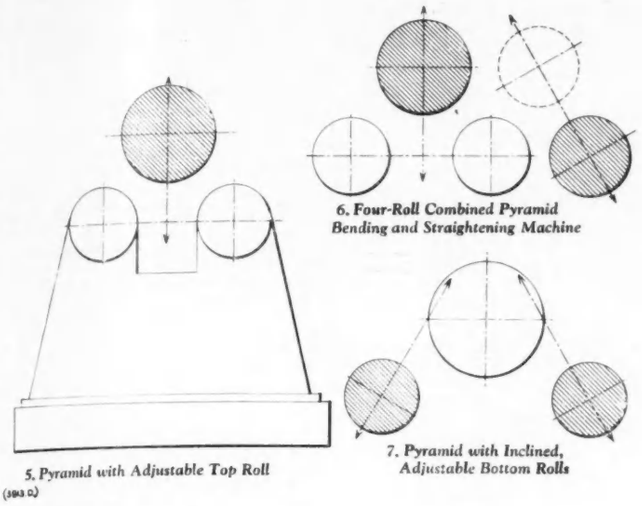
Operator-view and control is better than with the vertical type and inspection or check of curvature can more easily be made at each end of the plate during rolling. Most machines are provided with longitudinal grooves along the lower rolls to assist in gripping the plate and these may be used for initial alignment also. Cylinders narrower than the roll length are rolled in the centre of the rolls where equal distribution of roll flexure enables a balanced cylinder to be produced. For bending cones or special shapes requiring the use of shim plates during rolling, horizontally-disposed rolls are essential.

To summarise, vertical rolls are only recommended for limited range work where cramped space and infrequent use are more important considerations, and it is significant that considerably less than one per cent. of plate bending machines manufactured to-day are of the vertical-roll type.

SUPPORT-ROLLERS FOR HORIZONTAL PLATE BENDING MACHINES

Where the working length of the rolls exceed ten or twelve feet it is customary to employ one or more support-rolls along the length of the bottom rolls (Fig. 3). This enables smaller-diameter bottom rolls to be used than would be necessary without support-rolls and consequently permits the close roll-centre relationship essential in maintaining a minimum flat at the plate edge.

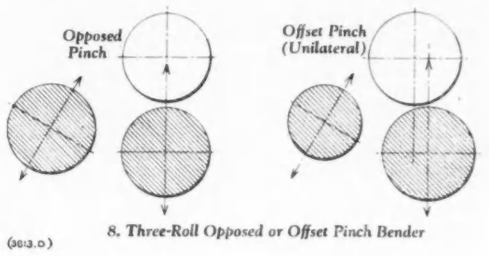
Where machines with long rolls (of the order of 16 ft. or more) are required to bend short, narrow plate of a thickness which would cause undue deflection of the top roll, a travelling yoke



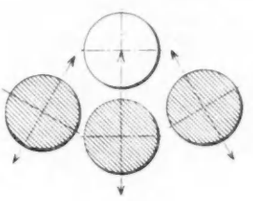
5. Pyramid with Adjustable Top Roll

6. Four-Roll Combined Pyramid Bending and Straightening Machine

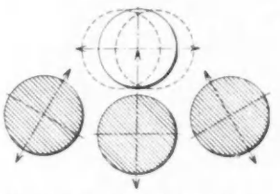
7. Pyramid with Inclined, Adjustable Bottom Rolls



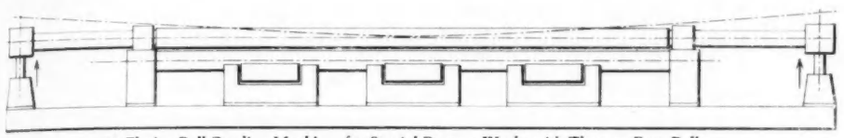
8. Three-Roll Opposed or Offset Pinch Bender



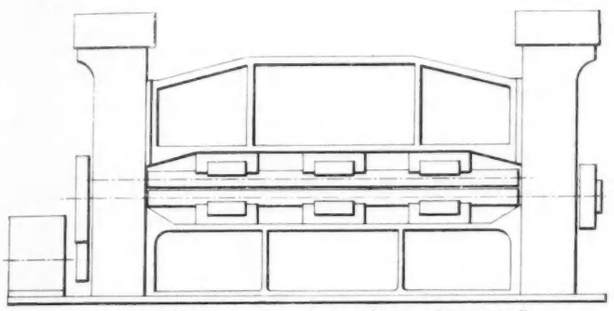
9. Four-Roll Pinch Bender



10. Universal Four-Roll Pinch Type Machine for Bending and Straightening



11. Flexing Roll Bending Machine, for Special-Purpose Work, with Three or Four Rolls



12. Shipyard Rolls, with Beam-Supported Top and Bottom Rolls

"ENGINEERING"

Figs. 5–12 Types of horizontal plate bending machines.

is sometimes used capable of being adjusted along the machine bed, with the effect of reducing the deflected length of the top roll. Such a device, which can be removed when working over the full length of the roll, is of special value in increasing the rated capacity and accuracy when the machine is used for bending narrow, heavy plate. (Fig. 4.)

PYRAMID AND PINCH-TYPE ROLLS

Two main groups of horizontally disposed rolls are now most commonly used throughout the fabricating industry—pyramid and pinch; typical arrangements are shown in Figs. 5 to 12. Both types have a number of different forms, with emphasis either on ease or speed of control or operation, width of plate thickness range, prime cost of machine and accuracy of finished product. It is not intended to deal with rolls for sheet-metal work which are almost without exception of simple and light pinch design. Before comparing in detail the constructional features of the various designs, some comparison of the virtues and limitations of each type may be of interest.

In the United States of America, where markets for water, gas and oil pipelines exist on a far greater scale than elsewhere, special emphasis has been laid on machines of the pinch-type. In the same way the opportunity for rolling long and consistent runs of tanks or containers justifies the trend towards a high output, limited purpose machine for projects in medium thickness (up to $\frac{3}{4}$ in.) plate. In Europe and elsewhere where repetitive work is infrequent or on a much reduced scale more versatile machines are preferred and the pinch-type machine is in much lower demand than the pyramid type. For example it is claimed by one American manufacturer that 99 out of 100 of their orders are for pinch-type rolls; on the other hand records of one of the largest European manufacturers of plate-rolls, doing a high proportion of export work, show that less than 20 per cent. of their orders are generally more suitable, in the normal course of events, for the pinch-type machine.

The implication is that this type of machine is a comparatively modern development of the Western world. This is not so. Pinch-type machines with three or four rolls up to heavy duty sizes, as for 16 ft. by $1\frac{1}{4}$ in. capacity, exist which still carry out the work for which they were designed over thirty years ago. Through increasing opportunity for standardised fabrication work, especially repetition pipe work, the pinch-type machine has gained greatly in demand at the expense of the pyramid rolls, but it is very unlikely that the pyramid machine will be entirely superseded.

The demand will continue for the pyramid machine, however, particulariy large-capacity machines ($\frac{3}{4}$ in. plate and upwards) and in newly developing centres of industry where its advantages for general purpose work and its lower cost are of primary importance. It should be observed here that a new development of the pinch-type machine recently introduced in the United Kingdom marks a very progressive stage in the development of plate-bending machinery, and combines the merits of both types of machine with certain additional features of special value. This machine, which is of four-roll design and has a horizontally-adjustable top roll, is likely to supersede the conventional three-roll pinch-type machine.

TABLE I.
QUICK REFERENCE CHART INDICATING BEST APPLICATIONS FOR MACHINE TYPES

Special advantages: i.e., most suitable for	3-Roll pyramid	4-Roll pyramid bender and straightener	3-Roll pinch	4-Roll pinch	4-Roll universal	Shipyard rolls	Vertical hydraulic roll/press
General purpose work. (With or without shim plates)	×	×	.	.	×	×	.
Pre-setting edges	.	.	×	×	×	.	×
Plate straightening, as well as bending	.	×	.	.	×	.	×
Large diameter vessels	×	×	.	.	×	×	×
Production piework	.	.	×	.	×	.	.
Quick-pass work	.	.	×	.	×	.	.
Interchangeability of top roll over wide dia. range	.	.	×	×	×	.	.
Cone rolling	×	×	.	.	×	×	.
Hot work	×	×	.	.	×	×	×
Ability to bend sheet below normal capacity	.	.	×	×	×	.	.
General purpose static bending	×	×	.	.	×	×	

TABLE II.
EXPECTED LENGTHS OF RESIDUAL FLAT FOR PLATES OF VARYING LENGTH AND THICKNESS AFTER BENDING IN PYRAMID ROLLS

Plate length	in. $\frac{1}{4}$	in. $\frac{3}{8}$	in. $\frac{1}{2}$	in. $\frac{3}{4}$	in. $\frac{1}{8}$	in. $\frac{7}{8}$	in. 1	in. $1\frac{1}{4}$	in. $1\frac{1}{2}$
ft. in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
4 0	3	4	4	4	$4\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{2}$	7	$8\frac{1}{2}$
6 0	3	4	4	4	$4\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{2}$	7	$8\frac{1}{2}$
8 0	3	4	4	$4\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{2}$	7	$8\frac{1}{2}$	$8\frac{1}{2}$
10 0	4	4	$4\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{2}$	7	7	$8\frac{1}{2}$	10
12 0	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{2}$	7	7	$8\frac{1}{2}$	$8\frac{1}{2}$	10
14 0	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{2}$	7	7	7	$8\frac{1}{2}$	10	—
16 0	$4\frac{1}{2}$	$4\frac{1}{2}$	7	7	7	$8\frac{1}{2}$	$8\frac{1}{2}$	10	—
18 0	$4\frac{1}{2}$	$5\frac{1}{2}$	7	7	7	$8\frac{1}{2}$	10	10	—
20 0	$4\frac{1}{2}$	7	7	7	7	$8\frac{1}{2}$	10	—	—

The above figures are based on a selected standard range of pyramid machines of appropriate roll diameter and roll centre to each size of plate specified.

The above Table I summarises very briefly the comparative merits of various types of three and four-roll pinch and pyramid machines, and should be used in conjunction with the following

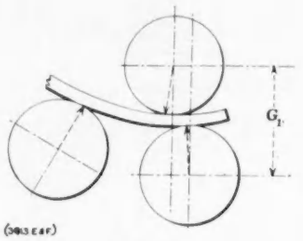


Fig. 13 Close gap.

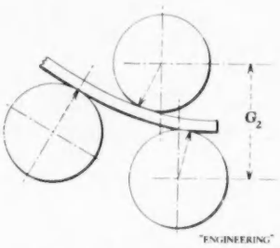


Fig. 14 Wide gap.

sections which deal with the considerations in detail.

FLATS AT PLATE EDGES

For pressure vessel work the absence of any flat whatsoever at the joint is essential and separate presetting of the plate edges in a press worked either cold or hot, or alternatively removal by cutting off the flat ends after rolling is common practice whether rolling is carried out in pinch or pyramid-type machines. The length of flat left at the ends of the plate after rolling in a pyramid machine with fixed bottom roll centres is a function of the roll centres. This is not entirely true in the case of the pyramid-type with inclined adjustable bottom rolls in which the centres vary with the degree of adjustment. The thicker and longer the plate, therefore, the greater the amount of residual flat. The length of flat cannot be described simply as so many times the plate thickness, Table II shows the amount of flat that may be expected for varying sizes of work. In the pinch-type machine residual flat is greatly reduced. Again, it is commonly described as so many times the plate thickness, but the amount of offset of the pinch-rolls and the pressure or gap has an influential bearing on this (Figs. 13 and 14).

As a general guide, for equal sizes of plate, the average pinch-type machine produces only one-sixth of the length of flat left by pyramid rolling. Some residual flat must and does remain; but it is insignificant for most work, especially on larger diameters.

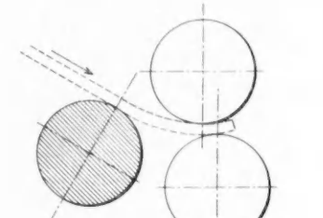


Fig. 15 Stage I. Preset first edge.

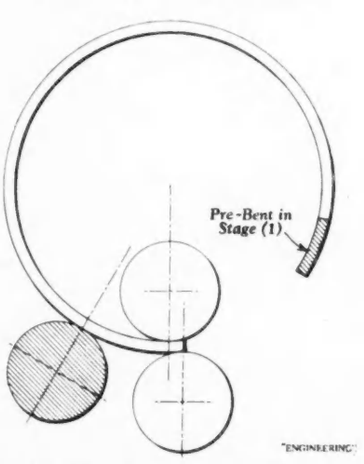


Fig. 16 Stage II. Roll cylinder, automatically bending up to edge on trailing end of plate.

EDGE BENDING AND ROLLING ON PINCH-TYPE MACHINE

To curve plate edges on the three-roll pinch-type machine the procedure is as follows.

Set the bending roll to the correct position for bending the plate in one pass through the machine to the required final diameter, the correct positions for different work diameter being found by experiment or previous record or chart. Enter the flat plate over the bending roll (Fig. 15). Roll the leading edge for a distance of 6 to 10 in. depending upon size of plate. Reverse the rolls, remove the plate from the machine and turn it round. Then enter the plate with the curved edge leading into the pinch-rolls from the opposite side (Fig. 16) and roll to desired curvature or complete cylinder in a single pass. As far as possible single-pass work should be carried out on pinch-type machines; the temptation to rock the plate forwards and backwards while working to a template should be avoided as this leads to difficulty in maintaining consistent curvature. It usually pays to pre-set one side of the whole of a batch of plates and lift them over and reverse them through the machine in a second operation.

Pre-setting on a four-roll pinch-type machine is carried out differently, the plate usually being static while working the edge. It is nevertheless very suitable for curving heavy plate ($\frac{3}{4}$ in. upwards) eliminating the need to remove and reverse the plate. The sequence is as follows:

Enter the plate from the right-hand side until the leading edge is gripped between the two pinch-rolls (Fig. 17). Raise the right-hand bending roll progressively until the desired curvature is obtained. When completed, lower the bending roll to its original position and pass the plate fully through the machine; repeat the operation with the left-hand bending roll, roll the plate forward (to the right) and round in one pass, or with reverse passes in the case of heavy plate, to the required diameter.

Bending in the pyramid machine is a familiar operation. Here too, however, the fewer the passes to achieve the desired diameter the better. In clutch-controlled machines, it is frequent practice in the first two or three passes to apply pressure of the top roll progressively while the plate is passing through the rolls, to save time, and finish roll to a consistent radius in later passes. If the plate edges are pre-set before rolling the number of passes is reduced very considerably, final diameter being achieved in larger cylinders in a single or double pass only.

The variation of the pyramid machine with adjustable inclined bottom rolls (Fig. 18) deserves some attention. This machine can be used as a pinch-type machine for edge setting, but only with considerable inconvenience as the plate is steeply tilted during the preparation of the edge. Its main virtue is that, for heavy plate, the bottom roll-centres are wide, and the load on the top roll consequently reduced, but moving as they do in inclined slideways, bottom roll-centres are automatically reduced as the rolls are adjusted up to work on thin plate or to small diameters, thereby providing a slightly increased capacity at the top and bottom ends of the plate range.

The operational functions of the universal four-roll pinch machine (Fig. 19) satisfy all the foregoing conditions and therefore provide the choice of each method of pre-setting or rolling according to the type of work, heavy or light, and operational experience available. Such a machine may be used as a three-roll opposed or offset pinch, four-roll pinch or inclined-roll pyramid bender with the additional feature of conversion quickly and simply to a four-roll machine for flattening plate.

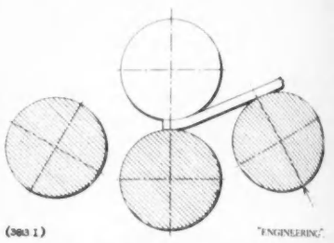


Fig. 17 Static edge-curving on four-roll punch type machine.

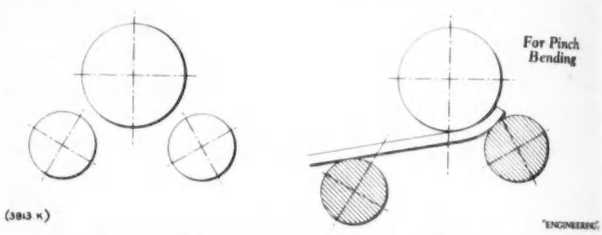


Fig. 18 Pyramid type with inclined adjustable bottom rolls.

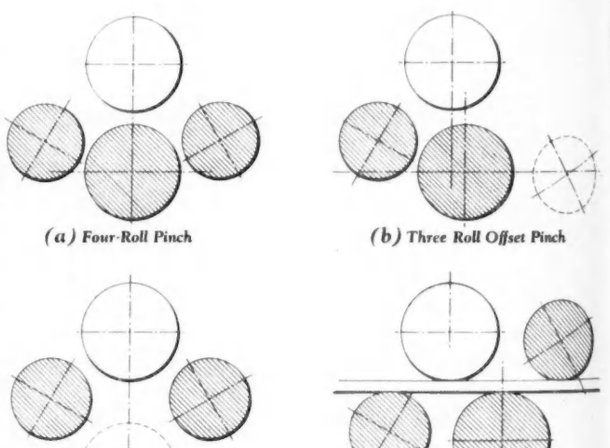


Fig. 19 The four-in-one universal pyramid/pinch bender, showing alternative roll settings.

MINIMUM DIAMETER OF CYLINDERS ROLLED

(*a*) Pyramid machines: In general the mini-

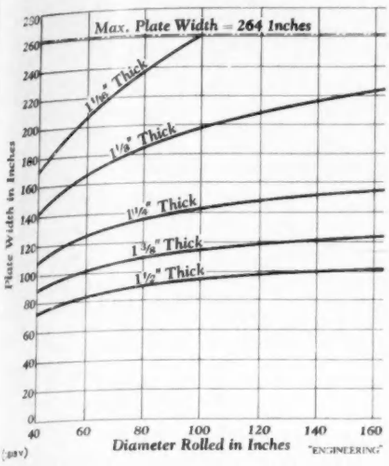


Fig. 20 Typical capacity chart for 22 in.—0 in. × 1 in. pyramid plate bending machine showing relation between maximum thickness and length of oversize plates with diameter.

mum diameter of cylinder capable of being rolled without pre-setting the ends is of the order of 1·3 × top roll diameter, but where the edges of the plate have been pre-bent, a considerable reduction in minimum diameter can be attained to the order of 1·15 × top roll diameter. One limitation, however, is the fact that the top roll is not normally driven. Plate at the lowest end of a particular thickness range may, therefore, not provide sufficient resistance to rotate the top roll when rolling has proceeded below a certain radius.

(*b*) Pinch-type machines on the other hand permit more effective rolling to small diameters on the light end of each plate-thickness range, one or both of the pinch-rolls normally being driven, and by virtue of the short bending moment between pinch-rolls. It is also assumed that pre-setting has already been carried out in the machine as a first operation, with its consequent contribution to smallness of diameter rolled. Some small advantage may also accrue to the reduction of work-hardening due to reduced passes in the pinch-type machine, especially when working stainless, clad or higher-tensile steel plate, or work-hardening light alloys.

Capacity charts are usually obtainable or can be compiled for each size of machine. Fig. 20 is an example of a typical chart giving operational data for a pyramid-type roll. From this it will be seen how the increase in permissible plate thickness is related to reduction in plate length and the relationship of width and thickness to diameter rolled. It will be observed, however, that assuming a constant roll-deflection factor, plate-thickness capacity increases only slightly with reduction in length.

It is the practice of some manufacturers of pinch-type machines to give their machines a dual plate-thickness rating; one rating for normal rolling and a reduced rating for setting the edges of the plate, usually of the order of 15 per cent. less. This can be inconvenient, as a machine is normally expected to be capable of edge setting the plate up to its maximum capacity; it is, however, logical in that efficient pre-setting to achieve the minimum flat possible relies on a positive pinch between the rolls, consequently shortening the contact centres and increasing the load on the pinch rolls. The load can be reduced by increasing the gap between the pinch-rolls, but this leads to increased length of residual flat.

PROTECTION AGAINST OVERLOAD AND USE OF STRAIN-GAUGES

In a pyramid machine, though detrimental practice, it is frequently possible to roll lapped plate edges through the rolls, and the roll disposition permits the pass of plate within the machine capacity without damage. The pinch-type machine demands some care to ensure that the gap between the pinch-rolls is not less than the thickness of plate to be rolled, and an over-size plate can cause severe damage before the machine can be stopped. It is good practice, therefore, to provide some form of protection in the top or bottom pinch-roll assembly either in the form of a shear-pin, breaker-block or heavily-loaded spring to combat this. In heavier sizes of machine, strain-gauges at each end of the bottom pinch-roll may be used in addition to the protective device with the special object of indicating the maximum safe pinch pressure that may be applied when pre-setting the edges of heavy plate.

When working heavy plate (1 in. and upwards) some definite virtue accrues to the use of strain-gauges to measure and indicate the load at each end of the work-roll (pyramid machine top-roll pinch machine top or bottom pinch-roll). In such cases it is a frequent practice to apply bending adjustment no longer on the basis of scales or metric indicators, but to load the bending roll up to the maximum using the strain gauges as a guide to the maximum adjustment permissible. Furthermore, this provides a protection against bad work due to excessive roll deflection and is an effective protective device against roll damage. A solution offered in one or two cases on the pinch-type machine to protect the pinch rolls against excessive load or the entry of over-size plate is to fit hydraulic vertical adjustment to the bottom pinch roll. It is extremely difficult, however, to ensure equal movement and accuracte parallelism at each end of the roll, and though with special hydraulic balancing control this can be achieved, as in the hydraulic press-brake, such a form of adjustment is not to be recommended. Strain gauges involve, of course, extra cost, but their protection against damage to valuable components of the plate rolls and the decrease in operating time-cycle can outweight this expense, especially in the larger sizes of machine.

CROWNING OF ROLLS TO COUNTERACT DEFLECTION

Owing to high loading factors, pinch-type machines are more conducive to "barrelling" in small diameter cylinders. This is not only due to the roll disposition, but also to the intrinsic qualities of the plate, the corners being weaker than the centre and tending to roll to a smaller diameter at the edges than the centre of the plate (Fig. 21). The effect is less pronounced on pyramid machines where the bending loads are less, owing to wider roll centres. "Barrelling" can, however, result from the employment of too-small rolls with too high a deflection factor, and in order to counteract this, "crowning" of the rolls may be resorted to, especially in the case of machines for long plate. This practice is to be avoided as far as possible, though where small pipe-diameter necessitates a small-diameter roll, "crowning" may be necessary. The degree of crown given, however, is suited only to a limited range of plate size, and is either insufficient for the heavier plate, permitting "barrelling," or excessive for thinner gauges causing reverse barrelling, i.e. gapping at the ends of the pipe. A further objection is that barrelling the rolls introduces difficulty in entering the plate squarely into the machine, and especially with light bending pressure, there may be a tendency for the plate to slew out of line during the pass.

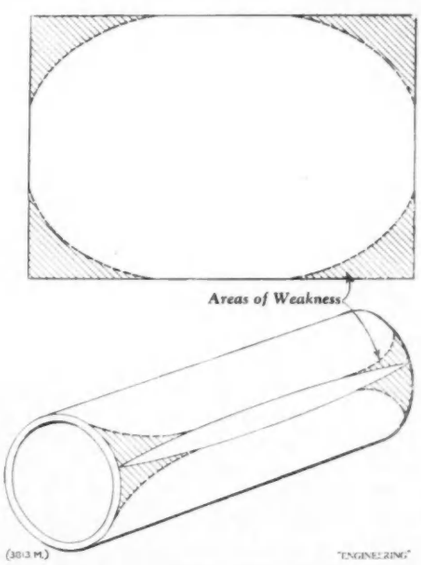


Fig. 21 How gapping or barrelling occurs. Weaker areas tend to bend to smaller radii.

To be continued

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BITUMEN-FIBRE PIPES

Several new products have been announced recently by the Universal Asbestos Manufacturing Company, Limited, Tolpits, Watford, Hertfordshire, and its associates. At the Building Exhibition last November, insulated hollow decking was displayed, and insulated sandwich constructions were introduced last July. More recently still, the subsidiary company, Union Fibre Pipes (Great Britain), Limited, has commenced the production of bitumen-impregnated pipes made of cellulose fibre.

Bitumen-impregnated fibre pipes are light easily laid and impervious to insects or corrosion.

Wood cellulose, in the form of waste paper, is pulped and placed in storage tanks, from which it is taken as required to the forming machines. The pipes are built up on mandrels by the addition of successive layers of pulp until the desired thickness is attained. They are then dried and removed. Lengths up to 8 ft. can be produced in this way, with diameters ranging from 2 in. to 6 in. A vacuum technique is employed for impregnation, the pipes being placed in containers which are then evacuated and liquid pitch introduced. After impregnation the containers are transferred to a cold-water tank which solidifies the pitch; the pipes are then unloaded. The final process consists of machining a 2 deg. taper on the ends so that they can be joined by a sleeve. Pipe and sleeve are shown in the illustration.

The advantages of the pipe are that it is unaffected by acids or alkalis, by insects or corrosion. It is lighter than earthenware, and being tough and resilient can be laid in a shallow trench, some 6 in. to 9 in. below a road surface. Concrete surrounds are not needed. Its flexibility allows it to follow unequal ground settlement. One man can carry more than 32 ft. of 4 in. pipe, and since it is in 8 ft. lengths, the number of joints that have to be made is reduced. In any event, jointing is extremely simple. A set of tools is available for field use which will cut the pipe and form the taper. Perforated lengths are available for drain and sewer pipes, and light sections for cable conduit. Bends and curved lengths are also made. Each type conforms with the appropriate British Standard.

Book Reviews

SOIL MECHANICS IN PRACTICE

The Design and Construction of Engineering Foundations. By F. D. C. HENRY. *E. and F. N. Spon, Limited*, 15 *Bedford-street, London, W.C.*2. (63*s.*) and

Foundations Design and Practice. By ELWYN E. SEELYE. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (16 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (128*s.*)

The design of any part of a structure involves a knowledge of the applied loads, the resulting internal stresses and deformations, the properties of the material used and the conditions governing failure. This applies to the foundations no less than to other parts of the structure, but the properties of the soil are much more variable and less easily determined than those of the ordinary materials of construction. Nevertheless, the development of soil mechanics during recent years has enabled foundation design to be placed on a more scientific basis, instead of depending, as in former times, mainly on empirical rules and intelligent guesswork based on practical experience.

These two books deal with the subject of foundation design and construction in very different ways. Mr. Henry's book is a comprehensive textbook intended, in the words of the author, " to sow the seeds of ideas by linking the design of foundations to the methods of structural analysis and soil mechanics, by indicating how other engineers have constructed foundations, and by examining the whole subject in the light of relevant research." Mr. Seelye's book, in contrast, is of the " engineer's pocket book " type—though the term would be a misnomer as regards size (10½ in. by 8½ in.)—consisting almost entirely of tables and diagrams of data on design of foundations and construction methods.

The first three chapters of *The Design and Construction of Engineering Foundations* are concerned with the principles of engineering geology and soil mechanics, leading up to the determination of the bearing capacity of soils and the conditions governing the settlement of foundations. Next, the author deals with individual footings, continuous footings and rafts, and describes the design of these in detail using both reinforced-concrete foundations and steel grillages. In the remaining chapters, various types of engineering construction are described—retaining walls, culverts, cofferdams, caissons, pile foundations and bridge abutments—and the important subjects of mining subsidence and underpinning are also covered. A number of worked examples are included in the text, and there is an appendix containing 100 exercise problems with numerical answers where practicable.

Some of the book makes rather heavy reading, and gives the impression that the author has attempted to compress too much information into a limited compass. On the other hand, in Chapter 2, he has surely dealt at unnecessary length with the principles of soil mechanics: the reader of a book such as this can reasonably be presumed to have a fair knowledge of these principles—in any case, several excellent text-books on this subject are available. The later chapters contain much useful data from British and American Codes of Practice. From the reader's point of view, it is no doubt handy to have such information included in the book. Since, however, the relevant codes are usually available to the designer, the space might have been more usefully devoted to reproducing some of the data to which reference is made in the text from publications not so readily accessible to the reader. By and large, the book is primarily suitable for the designer, but it will also form a valuable reference work for the specialist and for the postgraduate student, though the last mentioned may be somewhat bewildered by the bibliography of over 300 references.

In planning *Foundations Design and Practice*, Mr. Seelye has had in mind what he terms the " five dimensions of foundations: design, design data and criteria, costs, specifications and field practice." The first part of the book is devoted to the design of various types of foundation, retaining walls, culverts, dams and reservoirs. The evaluation of bearing pressure of soil is then considered, followed by two chapters on construction methods. The next two chapters deal with soil mechanics, embankments and pavements, and the final chapters include field practice, costs and specifications. In general, the idea of presenting a large amount of information in a concise form for easy reference is a sound one but, in details of arrangement and layout, the book leaves much to be desired. The illustrations are for the most part clear and well drawn, but many of the tables are reproduced direct from hand printing; the appearance and legibility of these would have been much better if printed in ordinary type.

The author does not appear to appreciate fully the impact of soil mechanics on foundation design and, judging by the many omissions and inaccuracies, his knowledge of this subject is somewhat limited. In Chapter 3, and again in Chapter 8, he gives tables of safe bearing capacity of soils. The specification of a fixed bearing capacity for a particular type of soil, analogous to a working stress for steel or concrete, is out of date except as a very rough guide. Apart from the obvious difficulty of exact identification of the soil, this concept ignores many important factors, such as the size and depth of the footing, and the variations in the strata underlying the foundation. This idea is again emphasised in Chapter 8 under the heading of evaluation of bearing power, while the subject of extensive site investigation, so necessary for large projects, involving the extraction of undisturbed samples, is neglected. The question of settlement due to consolidation, though mentioned, is not adequately treated. In the soil mechanics chapter, much miscellaneous information is reproduced from various literature on that subject, with little guidance to the reader as to how this should be used in design. On the first page of this section the author gives conflicting statements about the angle of internal friction of clay, and again, the connection between the permeability data in Table XII, page 13-22, and the formulae for ultimate bearing capacity under loaded footings on the same page, is quite erroneous. In several instances tables and diagrams are repeated in different chapters in order to save the reader who may be concerned with one particular type of problem having to refer to another part of the book for certain necessary data. This arrangement is reasonable, but it does not justify the diagram of stress distribution under a circular footing appearing no less than three times in the same chapter. Incidentally, a circular footing is an unusual form, and, in any case, it is not clear from the text how these curves can be used in practical design.

In the preface, Mr. Seelye states that his book is intended for " the practising designing engineer, the builder, the inspector, the architect, the teacher and the student." To produce a book which would cater adequately for such widely differing classes of reader would be well-nigh impossible. Design data in the form of tables and curves can be extremely valuable provided that the user has a thorough knowledge of the underlying principles, the assumptions and the practical limitations. In the hands of ignorant or incompetent persons such data may be misleading or even dangerous. For teaching purposes, a book of this type is not very suitable, except perhaps for occasional reference. Nevertheless, the book will have a broad field of usefulness, particularly for experienced engineers.

CLASSICAL PROBLEMS IN DYNAMICS

Elastic Problems of Single Machine Elements. Engineering Dynamics: Vol. II. By C. B. BIEZENO and R. GRAMMEL. *Blackie and Son, Limited*, 17 *Stanhope-street, Glasgow, C.*4. (90*s.*)

The German text-book *Technische Dynamik* is familiar to many engineers. This enormous work first appeared in 1939 (published by Springer) and a second edition came out in 1953. In producing an English translation, based on the latter, the publishers have decided to issue the work in four volumes, of which the second is under review. The title has been correctly translated as " Engineering Dynamics " although it is misleading, since dynamics is supposed to include statics. Volume II is effectively a book on advanced strength of materials and has been translated with great skill, and no little fortitude, by Mr. M. L. Meyer.

The authors set out to write a continuation of the usual text-books—a book on engineering mechanics for post-graduates, so to speak. Clearly, they took on a huge job. The result is a vast text, since the solutions to problems and methods of attack are not merely given in outline but are developed in great detail. The authors do not intend that the book should be read from cover to cover, and they have arranged things accordingly. Thus there are four self-contained parts in this volume, dealing with (1) beams and shafts, (2) springs and rings, (3) plates and shells, and (4) elastic instability. Under each of these headings there is a lucid, and very thorough treatment of a number of selected topics.

Within these chosen terms of reference, the book is almost unassailable. Indeed, its authors have written what is undoubtedly one of engineering's great works. It contains a mass of material which is explained and presented in an authoritative fashion. To be sure, it only covers a small fraction of present-day mechanics problems, but, if an engineer has a problem that is covered in " Biezeno and Grammel," he would be wise to consult the book. This English edition does not seem to have been produced to meet an obvious need, since the German version has been available for years and, by its very nature, it is of consequence only to those to whom it matters a great deal. But engineers will find it easier now to extract information from it; though such difficulty as has existed in the past was more likely to be one of mathematics than of language.

The appearance of the English edition is not of vital importance to the research worker. For one thing, it cannot be claimed that the book presents a particularly up-to-date account of engineering mechanics, since it has a distinctly traditional flavour. Many of the references given are to very old papers indeed, and some have acquired a quite respectable antiquity. The references to continental literature outnumber those to all the rest by more than five to one. Of the non-continental literature, the most quoted is this country's, but the latest British research paper referred to is dated 1918. In fact, the book can scarcely be said to present the current state of affairs as regards any of the topics treated. Of course, the validity of solutions does not change with the passage of time; but methods of finding them improve and their scope is increased.

While other text-books cover most of the ground quite adequately—notably those of Professor Timoshenko—this volume contains detailed treatments of many problems in such a form that it cannot fail to be of use on occasion. The non-specialist will have neither the need nor the desire to wade into *Engineering Dynamics* even if he has the mathematical equipment. It is for the specialist that the work is intended,

and, up to a point, it will serve him well. Research engineers will not submit to being "led" by the authors (as the preface suggests), but they will be glad of the new accessibility to solutions of classical problems.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Corrosion Preventives and Lubricants. MOBIL OIL CO. LTD., Caxton House, London, S.W.1. Industrial Technical Bulletins Nos. 9 to 13. Mobil rust and corrosion preventives; Mobil Etna Oils Nos. 2, 3, and 6, lubricants with wear-resistant additives and creep-resisting adhesive agent; Mobil oils for textile spindles; Mobil Etna Oils SS, special-purpose free-scouring oils for the textile industry; Mobil Viscolite oils, heavy-duty bearing lubricants for rough-purpose machinery with adhesive agent. Series of technical information sheets.

Light Current Junction Boxes. AUTOMATIC TELEPHONES AND ELECTRIC CO. LTD., Strowger Works, Liverpool 7. Junction boxes for telephone, public address, signalling and other light current circuits. Mild steel construction with centres fitted with rubber grommets so that cables can be run out from each end. Bakelite connection blocks. Designation labels on underside of lid. Illustrated leaflet 1300/1/E.

Standard Plugs and Sockets. PLESSEY CO. LTD., Kembrey-street, Swindon. Comprehensive data on the range of "Standard" plugs and sockets manufactured by the company. Not only are details of the connectors and accessories in current use given, but replacement types for discontinued and obsolescent components are indicated. Complete Air Ministry comparator tables arranged for easy reference. Illustrated brochure.

Reinforced Plastics. SARO LAMINATED WOOD PRODUCTS LTD., Folly Works, Whippingham, East Cowes, Isle of Wight. The company's facilities for design, testing and making reinforced plastics—silicones, melamine, phenolic resin for the electrical industry; polyester resins for general industrial and structural use. Illustrated brochure.

Polythene Tubing. THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD., Mercury House, Theobald's-road, London, W.C.1. Telcothene tubing for industrial, domestic and agricultural purposes. Properties, installation, applications; data on Telcothene tubing for cold water services. Illustrated technical descriptive leaflet.

Portable Arc Welding Equipment. ENGLISH ELECTRIC CO. LTD., Kingsway, London, W.C.2. Single operator portable arc welding equipments covering current ranges from 34 to 315 amperes, 59 to 450 amperes and 116 to 625 amperes, respectively. Technical descriptions, electrical data and power factor correction curves. Illustrated pamphlet WA/133.

"Speedees" Electrodes for Mild Steel. ENGLISH ELECTRIC CO. LTD., Kingsway, London, W.C.2. "Speedees" electrodes for the easier, faster and more economical welding of mild steel. Physical properties of the weld, welding characteristics, deposition data and electrode details. Illustrated pamphlet WA/132.

Sub-Miniature Capacitors. PLESSEY CO. LTD., Kembrey-street, Swindon. All-aluminium sub-miniature electrolytic capacitors for transitional circuits where physical size is essential. Details of design. Range of capacitance from 1 to 50 microfarads and for operation at peak voltages, from 1·5 to 70 volts. Illustrated leaflet.

Permutation Welder. SCIAKY ELECTRIC WELDING MACHINES LTD. Falmouth-road, Slough. Details of three special-purpose machines which show how resistance welding has been employed to solve difficult problems. Technical details. Illustrated brochure.

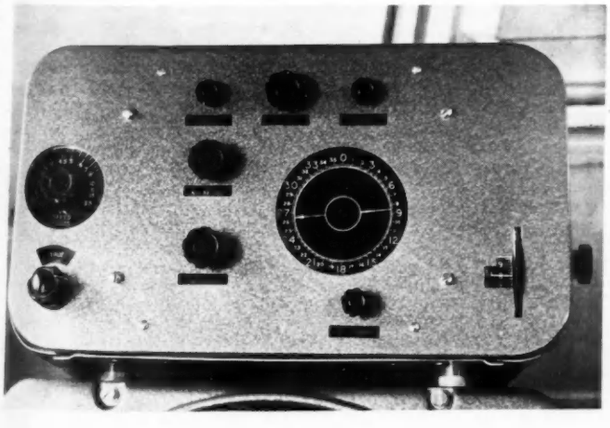
Pipeline Filter. BIRFIELD INDUSTRIES LTD., Stratford House, Stratford-place, London, W.1. "Straitflo" strainer, installed directly in pipeline; for water, steam, oil, air or gas supply lines. Specification leaflet, illustrated.

TRUE MOTION RADAR

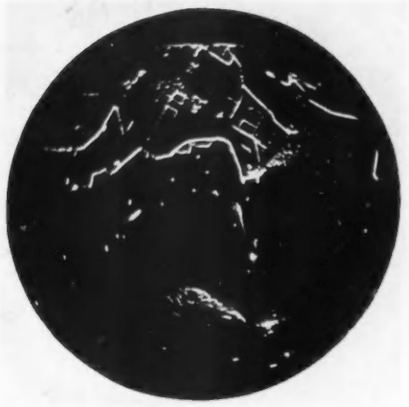
ADVANCE IN MARINE NAVIGATION AID

Although many thousands of ships are now equipped with marine radar, collisions still occur and, when it has been possible to analyse the causes, failure of the human element has usually been found to be the determining factor. Marine radar in current use presents a picture of the apparent motion of all targets within range relative to "own" ship, which appears to be stationary in the centre of the screen. In such a display, it is not possible to tell directly which targets are ships in actual motion and which are stationary buoys. In bad visibility, in order to take effective avoiding action in a crowded waterway, it is essential for the navigator to have a picture of the true course and bearing of the other ships, and it is in the plotting of these values from the relative motion picture on the plan-position indicator that the human element sometimes fails. To overcome this, an entirely new system of presentation has been developed by Decca Radar, Limited, 1-3 Brixton-road, London, S.W.9, in which for the first time the true movements of all objects within range, including "own" ship, are shown directly on the cathode-ray tube.

In the new Decca type TM 46 radar, which provides for both true-motion or relative-motion displays, as desired, the display of true motion is obtained by feeding compass and speed information into a small resolver in a Trackmaster unit mounted on the viewing unit. The speed and direction of "own" ship are here converted into movements of east-west and north-south. These movements control the amount of current in the off-centring coils of the display unit itself and affect the position of the electrical centre, that is, the position of "own" ship about which the trace rotates. On a compass-stabilised display, when the electrical centre moves in harmony with the course and speed of "own" ship, the effect on the P.P.I. is to present true motion, that is a "bird's eye" view of the situation, since the component of "own" ship 's course and speed normally present in the apparent motion shown on a conventional display has been entirely removed. The amount of movement imparted to the display depends on the radar scale in use and is automatically adjusted when the range scale is altered.



The Trackmaster unit accepts information of the course and speed of "own" ship and converts it to east-west and north-south movements controlling currents in the off-centring coils of the display unit. This causes the electrical centre to move in harmony with "own" ship's movement.



In this true motion P.P.I. photograph "own" ship is steering about 340 deg., approaching a sharp bend in the Schelde at Bat. The buoyed channel is immediately apparent and the traffic situation in the river can be seen at a glance. A large ship on the port beam is moving up river in the channel. A small vessel on the port bow is passing outside the channel buoys and, astern, one large and one small ship are following.

The speed of "own" ship is fed into the Trackmaster unit either by hand or automatically from the ship's log. The estimation of the course and speed of other ships is made by observing the afterglow trails behind those ships' echoes. A mechanical bearing cursor, with parallel lines, can be used to read these courses when a high degree of accuracy is required.

Range rings and a variable range marker appear as concentric circles around "own" ship and have normal radar accuracy, being independent of any movements imparted to the display. An electronic bearing marker is provided to measure bearings of other vessels with a greater accuracy than is possible by conventional mechanical methods. The marker appears as a radial electronic line centred on the position of "own" ship, and bearings are read from a calibrated dial.

Since "own" ship is continually moving over the face of the tube in the direction of the ship's course, the range of warning ahead is steadily being reduced and would eventually be nil unless the position of "own" ship were reset. Resetting is effected simply and speedily by shift controls and "own" ship can be positioned anywhere on the face of the tube. After resetting, the true-motion picture is again developed, within 20 seconds.

Decca TM 46 radar, which operates in the frequency band 9,320-9,500 Mc/s., provides ranges of 1, 2·5, 5, 10 nautical miles radius on both true motion and relative motion; in relative motion only, ranges of 25 and 45 nautical miles are also available. The accuracy of the range marker is within 2 per cent., and of the range rings within 1 per cent., of the range scale in use. The discrimination is 25 yards on the shorter ranges. The bearing accuracy is within 1 deg. on responses near the edge of the tube, and the discrimination is approximately 1·2 deg.

The existing Decca 45 (relative motion) radar can also be converted to give a true-motion display, provided that the ship has a transmitting compass, by installing a Trackmaster unit, which Decca are making available separately.

FIRES IN SHIPS

With a few notable exceptions like the case of the Empress of Canada, serious shipboard fires are becoming comparatively rare events; but the great majority of big fires start as small ones, and statistics show that small fires are still much too numerous for the peace of mind of those who build, own, operate and repair ships. There was strong support, therefore, for the symposium on "Fires in Ships," organised as a joint meeting of the Institution of Naval Architects and the Institute of Marine Engineers, which was held on October 23 in the Institute's hall in London. Titles and authors of papers are given at the end of this report.

CAUSES AND EXTINCTION

Mr. Welch's paper was based on a study of the reports of fires which had occurred in British merchant ships during the five and a half years from January, 1951, to June, 1956. In this period the number of fires reported totalled 697, of which 236 occurred at sea. Of the grand total, 236 fires occurred in cargo or in cargo spaces, 212 in accommodation and stores, 165 in machinery spaces, 24 in coal cargoes (these are not included in the 236 cargo-space fires mentioned above) and 46 in coal bunkers, and 14 occurred in tanker cargo and cargo spaces. Of the fires classified as "serious" or which resulted in loss of life, the largest number (25 out of a total of 57) occurred in machinery spaces. Of the total of 697 fires, nine resulted in the constructive total loss of the ships concerned, the largest of which was the Empress of Canada (20,325 tons gross) and the next largest, the troopship Empire Windrush (14,414 tons gross). An interesting point was that, of 35 instances of crankcase explosions, none resulted in a major fire. For initial attack, two-gallon foam extinguishers, Mr. Welch considered, "could hardly be bettered." They should be followed by the use of ten-gallon or 30 gallon extinguishers, though CO_2 and dry powder extinguishers had advantages in certain cases. Steam was allowed as the smothering medium in the boiler rooms of cargo ships, but an ample supply could not be relied upon if the boilers were of the water-tube type. CO_2 probably offered the best chance of complete extinction. The closing of openings was the part of the fire-fighting organisation which was most likely to break down, and crews should be educated not to leave doors open behind them when a fire occurred. Further improvement in fire-fighting at sea appeared to lie in an extension of "fire-mindedness" and training, more means for fire detection in holds, greater cleanliness in machinery spaces, and the placing of oil tanks where they could not become involved by flame from a major fire sweeping up the inside of machinery casings.

PRINCIPLES OF FIRE ORGANISATION

Lieut.-Colonel Bates's "text" was that the first requirement for the success of any fire-fighting organisation was constant awareness of the need for it. The introduction of new materials of construction, of high heat conductivity, presented new problems. Fire organisation should aim, first, at preventing the lapses by individuals which resulted in such fire risks as those due to cigarette ends, accumulated rubbish, oily rags, etc. The cigarette risk was very real in a passenger liner at sea. As an example, he cited one ship in which, in one voyage, some 2,100 tons of fuel oil would be consumed, releasing some 87,000 million B.Th.U.—a "colossal" fire potential, were it not that "those flames will have been guarded to the limit of human skill and duty." During the same voyage, however, some 300,000 cigarettes would also be burned, entailing the ignition of 300,000 matches or lighters—600,000 fire risks, distributed haphazard about the ship. Though representing a measured fire potential of only 17 B.Th.U. each, they constituted by far the greater fire hazard. The best fire warning, in the author's opinion, was the seaman's nose, which had been known to detect a cargo fire 14 hours before its existence was confirmed. Sprinklers and smoke detectors were in common use and were well tried, but they had the drawback that a sizable fire must exist before they could function. Their great value was that they maintained a continuous watch. To meet fire risks in port, which were more numerous than those at sea, he suggested that large ports might maintain a corps of trained fire and cargo watchers, available to shipowners on demand. In tackling a fire, promptness was essential and, for a time, the man who discovered the fire carried more responsibility than the master of the ship; training should aim to make the right action instinctive. The paper concluded with a tabular statement of the main details of all the fire incidents which occurred, during 12 consecutive years, in two large passenger liners. Of the total of 49, only 14 occurred at sea, where good discipline could be maintained; and, as the ships spent more time at sea than in port, Colonel Bates estimated that the likelihood of an incident was four times as great in port as at sea. Of the 35 fires in port, 13 were attributed to smoking and probably many of the 12 recorded as "cause unknown" were due to smoking also.

FIRE ORGANISATION IN THE NAVY

The Royal Navy gained much fire-fighting experience in the 1939-45 war and learned some valuable lessons. These were, according to Mr. Carter and Captain Hogger, first, the vital importance of training in all forms of damage control and particularly in fire fighting, and that the men should be trained as a team. Second, there must be good and adequate equipment, well distributed about the ship; third, that, as far as possible, combustible materials must be kept out of ships; and fourth, that every man must know his ship thoroughly. These lessons have been applied, with the result that, of 101 fires reported in H.M. ships during 1955, only six were classified as major and eight as medium. Welding operations were responsible for 21 of the fires reported, the disposal of smoking materials was blamed for 17, and breakdowns of cable insulation caused eleven. Preventive measures include fire-retardant impregnation of all wood except such as may come into contact with food, the use of fire-retardant paint, and a protective sheath of Neoprene over the insulation of electric cables. A fire in any compartment should be capable of being dealt with by a 40 ft. length of hose from each of two hydrants. The standard hose size is 2½ in., but a 2 in. hose is now used in congested spaces, for ease of handling. The fire-main working pressure is 75 lb. per sq. in., but 100 lb. pressure is being adopted in all future carriers and cruisers, and this may become standard for other ships also. For fires involving flammable liquids, foam is the most effective extinguishing medium, a stiff foam being used for open fires and a more free-flowing type for obstructed spaces such as machinery-space bilges. Spray systems a refitted in compartments where a severe fire risk exists, such as magazines, aircraft hangars, spirit rooms, etc.; in some cases, these are operated automatically by electrical fire-detectors. In addition to portable extinguishers, fixed foam tubes are built into the structure of machinery spaces, and there is also a steam drenching system; both systems are controllable from outside the compartment. All ships carry the foam-type portable extinguishers for flammable-liquid fires, water-type for carbonaceous fires, and CO_2 extinguishers for electrical fires, and also portable or semi-portable Diesel-driven emergency pumps. For the clothing of fire-fighting parties, fearnought suits (very heavy woollen cloth) have been found most suitable, with gauntlets of the same material and headgear consisting of the standard anti-flash helmet and hood.

RESEARCH ON SHIP FIRES

The paper by Mr. Clarke and Mr. Hodges reviewed the fire resistance of different types of structures, the behaviour of typical materials when exposed to fire, the toxicity of combustion products, and methods of fire detection and extinction. Some interesting figures were given regarding the effectiveness of sprinklers. Out of 55 reported incidents, the sprinklers provided the first warning of fire in 44 instances and in 30 they put out the fire before any person reached the scene. Thirteen of the incidents occurred at sea, 17 in port, and 25 in ships under construction. In two instances the water supply was not connected, but the systems operated under air pressure and gave the alarm. The most striking lesson from major ship fires was that disasters had occurred because a number of precautions had failed simultaneously. Provision should be made for shutting off fuel supplies automatically in the event of fire. It should be impossible for the oil to spread to accommodation spaces.

DISCUSSION

The discussion was opened by Sir Austin Anderson, the chairman of the Chamber of Shipping, who made the point that the increasing adoption of air conditioning, with its associated ducting was a factor to be considered in planning means for fire prevention and extinction. Mr. J. Lenaghan, of the Fairfield Shipbuilding and Engineering Company, referred particularly to the fire risks to ships under construction inherent in the use of welding, and commented also on the necessity to employ reasonably young and intelligent men for fire patrols. The cost of a good fire patrol might amount to 0·3 per cent. of the cost of a large passenger liner, but it was money well spent. Mr. R. S. MacTier, C.B.E., of Alfred Holt and Company (the Blue Funnel Line), spoke of the difficulty of tackling engine-room fires, which often could be attacked only from above. A better approach was via the shaft tunnel, and it was the practice in his company's ships to keep smoke helmets and other first-aid equipment in a convenient position near the tunnel exit aft. In the Blue Funnel Line, smoking in the engine room was forbidden, and engine-room fire drills were held weekly. All senior officers were required to take a fire course, as a condition of promotion.

Commander R. Grey, R.N., who followed, reiterated the dangers of cigarette ends and said that even the Royal Navy had not found a solution to that problem. He did not believe that safety was to be found in more rules and regulations; it could only come from more publicity and better training. Mr. A. R. G. Wray, chief fire officer of the Central Fire Station, Birkenhead, suggested smoking should be permitted in specified areas and forbidden, under severe penalty, anywhere else. Commander W. Walmsley, R.N. (ret.), Deputy Chief Constable of the Admiralty Fire Service, regarded welders as the biggest menace in a shipyard or dockyard, but considered that the blame rested less with the individual welder than with those in authority over him. Dr. E. G. West (Technical Director, Aluminium Development Association), referring to the structural use of aluminium in ships, said that its major drawback in a fire was not its low melting point, but the loss of strength at a comparatively low temperature. His Association would welcome discussion on the problem of how best to insulate aluminium structur almembers.

The papers presented were: "Survey of the Causes and Methods of Extinction of Fires in Ships," by Mr. F. J. Welch, Engineer Surveyor-in-Chief, Marine Division, Ministry of Transport; "Principles of Fire Organisation in Ships at Sea and in Port," by Lieut.-Colonel A. G. Bates, D.S.O., M.C., of the Cunard Steam-Ship Company, Limited; "Naval Procedure in Relation to Fire Organisation," by Mr. L. T. Carter, B.Sc., R.C.N.C., Assistant Director of Naval Construction, Admiralty, and Captain H. C. Hogger, D.S.C., R.N., Assistant Engineer-in-Chief of the Fleet; and "Research in Relation to Ship Fires," by Mr. S. H. Clarke, of the Department of Scientific and Industrial Research, and Mr. S. A. Hodges, M.B.E., Deputy Chief Ship Surveyor, Ministry of Transport.

Marketing

SERVICE BEFORE AND AFTER SALES

Tout Pour le Customer

Service is the talk of the moment. There is after-sales service and before-sales service. A young German chemist representing his company on their British agents' board said: "We score because we have a team of application engineers ready to help any firm with any problem in our field. I hear of a specialised need, or of trouble with our plant, and an English-speaking specialist is flown over within 24 hours." In less than two years this company have re-established their pre-war domination of the British market. But the Germans are not alone, nor are the Americans their only rivals. There has been in recent months a heartening revival among British companies.

Announcing their entry into the general food industry with a new range of sifting and screening machines, Thomas Robinson and Son, Limited, of Rochdale, the flour-milling engineers, place considerable emphasis on the advisory service they give to firms with a problem. Hitherto, relatively very few of their sifting and screening plants have been supplied to non-flour milling purchasers, because "Robinsons will not install a machine until thorough investigation has proved" its suitability. The new Food Industries Division is to have the backing of "a complete service covering all aspects of technical information and maintenance." Many British companies are energetically pursuing the same objective.

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G.E.C.'s Guide to Exports

The prospects of British exports, market by market and product by product, will be analysed at quarterly intervals by the General Electric Company and the results distributed to leading executives in industry. This was announced recently by Mr. Leslie Gamage, vice-chairman and joint managing director of the company, with the object of "helping British industry and trade to increase the nation's exports." Mr. Gamage, who is president of the Institute of Export, expressed his belief that a very large number of companies "have yet to take seriously the real and urgent need for exports" and that they will soon have this need thrust upon them "by the sheer force of economic pressure."

The G.E.C. guide is first-class. At a glance it is possible to see the state and prospects of 36 groups of manufactured products in 34 overseas markets. The selection of both products and markets is based on their importance to Britain's trade. Trends in world trade are indicated, and the description of the guide as "an overseas market barometer" is an apt one. Whether or not it will stimulate non-exporters "to have a go" will presumably depend on how severe the economic pressure forecast by Mr. Gamage proves to be. But it is refreshing to hear that one of the most successful exporting companies in the world consider "accurate market information is one of the most vital aids" to successful export trade.

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Rental Plan for Machines

The credit squeeze is a ray of sunshine for those who make it their business to finance the purchase of capital goods equipment. Increasingly, the enterprise of the finance houses is helping to make the Government's financial policy a more accurate weapon, by reducing its weight on capital investment. The inclusion of cars as productive equipment is debatable, and restrictive action by the Government has been foreshadowed. By and large, however, the financing of the use of commercial vehicles, tractors, farm machinery, contractors' plant, machine tools and other machinery is helpful and beneficial, particularly to the small and medium concern worse hit by the squeeze.

Bowmaker Limited, industrial bankers, recently announced a simple rental plan which applies to the products mentioned above (including cars) costing £400 or more. It is based on a monthly rental of £3 6*s.* 8*d.* per £100 of the cash price payable over a period of three years, the first six or nine months' payments to be made on delivery to comply with current regulations. The cost of renting a £2,600 machine tool over three years amounts to £3,042, or 117 per cent. of its price. The hirer is required to maintain and insure the vehicles or machines himself.

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Air-Mail Catalogues

An air-mail edition of a trade catalogue on compressed air equipment has been produced by the Consolidated Pneumatic Tool Company, Limited. The weight of 24 pages, including the envelope, is under one ounce. The information, well illustrated and giving full specifications, is printed on good quality non-transparent paper and is easy to read. The company express the hope that it will "at least indicate to overseas buyers a desire to deal with their inquiries promptly," and that it will enable them to select their needs without having to write for further information.

The question of trade catalogues is a sore subject with many overseas customers. Consolidated Pneumatic's move is in the right direction, but too few engineering companies take the trouble to present their products in the language of the country to which an attempt is made to sell them. In relation to the goodwill which can be built up by printing in, say, French, German and Spanish, the cost is negligible. It would be of considerable interest to have information from companies who have air-mail editions of their catalogues and from those who print their trade literature in foreign languages. Also, perhaps, from companies who go even further and translate their specifications into metric measurements.

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The New India

Sir Eric Coates and his ten colleagues have arrived in New Delhi to prepare a report for the Indian Government on the country's requirements for the expansion planned in the field of heavy engineering. They are to take a long view, extending beyond India's third five-year plan scheduled to be completed in 1966.

The Government of India clearly intend to build up a large engineering industry. For this they will need iron and steel plant, heavy machine tools, mechanical handling plant, control mechanisms, instruments and a wide range of other machines and equipment unlikely to be produced locally in significant quantities during the next decade. They will also need the most up-to-date plant and machinery for the setting up or expansion of basic industries—such as mining, chemicals, fertiliser, food and paper—and for agriculture. The needs are immense for capital as well as for capital plant. But there is likely to be intense competition to supply both needs, for India is the political key to the Far East, as Egypt is to the Middle East.

Sir Eric Coates will bring back much information, statistical and otherwise. But even before his return in a month's time British engineers can go out, with confidence that these needs exist, to find out precisely what they can supply. Technicians and technical advice are likely to be one of the first and most urgent requirements. Those who provide them are likely to supply the equipment and machines. India will be a stern test of salesmanship but, like Soviet Russia between the wars, she is likely to become—alongside China—one of the great capital goods markets in the world.

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KEEPING THEM RUNNING

Service Organisation for I.C. Engines

The importance of after-sales service and of quick supply of spare parts is constantly being impressed on British manufacturers to-day—particularly those who have large overseas sales. Among the many who had for some time realised the need were Petters, Limited, who have had a service depot at Burton-on-the-Wolds, Leicestershire since the war. Last year, to make full use of their facilities, the Brush group formed a new company—Petter McLaren Service Limited—which would cover spare parts and service for all current and obsolescent engines made by Petters and J. and H. McLaren Limited. The new company took over and extended the premises at Burton.

The range of engines for which these facilities are now available includes five current types of air and water cooled petrol and Diesel engines made by Petters; seven current types of Petter-McLaren, Petter-Fielding and McLaren; air and water cooled Diesel engines made by McLaren's; and obsolescent types made by Vickers Petter; Fielding and Platt; Brush; Atlantic; Fowler; Cub; and Coborn. Some of the last group date back to 1915. Such a large range (the size is from 1½ to 1,000 h.p.) naturally calls for considerable and precise paper work, for modifications to design naturally occur during a period of time, so to save space, micro-photographs are used, one set of negatives being kept at the depot and the

Each service engineer of Petter McLaren Service Limited is provided with a van equipped as a mobile workshop.

originals in a bank vault. "Recordak" equipment is used and includes a desk model for 16 mm. film, which can be used either as a camera or a projector; a 35 mm. camera which will handle drawings up to 20 in. by 30 in.; and a library reader taking both 35 mm. and 16 mm. film. It is estimated that 200,000 drawings, 160,000 engine record cards and 70,000 engine contract records have been filmed and filed to date.

WATCHING FOR FAULTS

Spares required for current types are drawn from the factories on a regular order. In the main office there is a three-dimensional Colordex control covering complaints of faults, which indicates the faulty part, the number of complaints of that part during four-week periods and the total number of complaints to date. A glance is sufficient to show if any one part is giving undue trouble, and a close liaison is maintained with the design department to keep them informed. The system also shows the average run of replacements required and so enables the orders for spare parts from the factories to be regulated. To cater for sudden demands, or large batch orders from overseas, a buffer stock is always carried.

Spares for obsolescent types cannot usually be supplied from the factories, and so the service depot has been equipped with two machine shops —one for light work and one for heavier. In them any part required can be manufactured; a certain amount of sub-contract work is also carried out.

Orders for spares arriving at the main office are handled on a Bradma machine which makes metal printing plates for each part, carrying such information as part number, description, basic cost and bin location. This is printed on to the forms and the number required added, so that any errors in copying are avoided. The system has proved so successful that one of the clerical staff formerly engaged on invoicing has been transferred to other duties. At the branch offices similar systems are being installed for routine work, and here too the branch managers report that they have noticed the time saving.

In addition to the spares service, there is an engine exchange scheme whereby a customer's engine can be replaced by a reconditioned one of the same type at a reasonable charge. Engines returned to the depot are sorted into types and then sent through the reconditioning shop in batches of one type. For example, one week petrol engines will be handled, and the next the smaller Diesels. The engines are first subjected to a wash in a steam and detergent bath, and then are completely stripped. The separate parts are checked and replaced where necessary, and the engines rebuilt on a roller conveyor. This leads directly to the test department (passing through a trap in the wall) where the engines are tried on load. The test completed, they pass to the paint booth and are then stored on steel racks. Larger engines follow a similar process in a separate section of the shop. During reconditioning, all more recent modifications are incorporated and the engines leave the shop with a 12 months' guarantee.

MOBILE WORKSHOPS

For home customers the country is divided into five regions with centres at Aberdeen, Glasgow, Leeds, Burton-on-the-Wolds and Staines. Some fifty service engineers, each with a van fitted as a mobile workshop, are attached to these centres, though they do not necessarily live in them. Overseas customers are catered for by the nine subsidiary companies of the Brush Group and by 123 agents. In particular, there is a series of agencies stretched along the Rhine where more than 1,000 barges use Petter engines. For use in very outlying spots where there is no proper agency, the company have produced cases of spares containing those items which are most frequently needed such as gaskets and springs. Some of the cases are fitted with Perspex covers and, since the parts can always be seen, it is easy for the customer to select the required item (even though he may not know its name) and for the agent to see when more must be ordered. Many parts that are in steady demand are pre-packed for dispatch, and much ingenuity has been spent in evolving a package which, once closed, cannot be opened without being torn. This is a necessary precaution to prevent the theft or " pirating " of parts.

EFFICIENCY, ECONOMICS AND EXPEDIENCY

ELECTRICAL ENGINEERING PROBLEMS TO-DAY

Mr. P. J. Ryle brought a refreshingly light touch to the subjects of engineering efficiency, economics and expediency, which formed the theme of his address as chairman to the Supply Section of the Institution of Electrical Engineers on October 24. These three nouns, he said, best expressed three broad aspects which the engineer must consider whenever he was engaged in design and planning. A simple example of the parts they played in the electrical world was one of the most self-contained and self-sufficient pieces of apparatus—the transformer. Its efficiency in the case of a large unit was about 99 per cent. and could not be improved, unless insulating materials and core steels capable of running at much higher temperatures than those now used were made available. The only other imaginable change would be the substitution of silver for copper for the windings. This, however, would only raise the efficiency from 99 to 99·1 per cent. and slightly decrease the running costs. On the other hand, the increase in capital cost would make the change uneconomic.

While as great advances as possible had been made in the fields of efficiency and economics, expediency aspects were quite important, especially as regards dimensions (owing to railway loading gauge) and weight (owing to lack of facilities at ports) such restrictions might lead to results less favourable to efficiency and economics than those which the designer would arrive at if he had a perfectly free hand, while now that large transformers had to be sited in densely populated areas, the ideal unit was not one of maximum efficiency or minimum overall cost but the machine which gave rise to the least noise.

GENERATING EFFICIENCIES AND TRANSMISSION-LINE CRITERIA

Dealing with the same three factors in relation to the problems of electrical generation and transmission, Mr. Ryle pointed out that while improvements in the efficiency of steam power stations were conceivable if higher temperatures and pressures were used, to obtain them would mean an uneconomic increase in capital cost. The efficiency of large hydro-electric generators, too, could not economically be increased; and although slight reductions in the hydraulic losses in the tunnels and valves were possible, these also could only be obtained at the expense of unjustifiable rises in both capital and running costs. The internal economics of a water power station or systems of stations might, however, sometimes be less important than their wider effect. For instance, every kilowatt-hour generated by water power, whether it happened to be economically produced or not, might be regarded as saving coal. The short-time availability of water power at times of national peak load might also go far to avert load shedding or the need for installing further steam sets.

Overhead transmission lines, continued Mr. Ryle, were in a class apart from most electrical apparatus in that they were exposed to lightning, snow, gales, aircraft, floods, subsidence and other effects which were almost beyond man's control. It was therefore justifiable to stretch the term efficiency to embrace the overall degrees of success with which the line performed its functions. The perfectly efficient line would never suffer any failures or experience any faults. Most of the line design levels were, however, only expedients which gave standards of service that had come to be accepted as fair; and the true criterion of optimum design was that the total annual cost of the line, plus the annual cost of the losses and outages should be a minimum.

The routing of transmission lines, too, often involved a triangular battle between overall efficiency, economics and expediency. For instance, two single-circuit lines were more expensive than one double-circuit line, but the latter was more subject to the simultaneous outage of both circuits. On the other hand, the double-circuit line required only one route instead of two which was often important in built-up areas and meant half the towers to desecrate the duke's deer park. The routing of lines also necessitated a compromise between the most efficient, in other words, the shortest, layout and the need for the operating engineer to have easy and quick access to them in case of trouble.

RIVER CROSSINGS

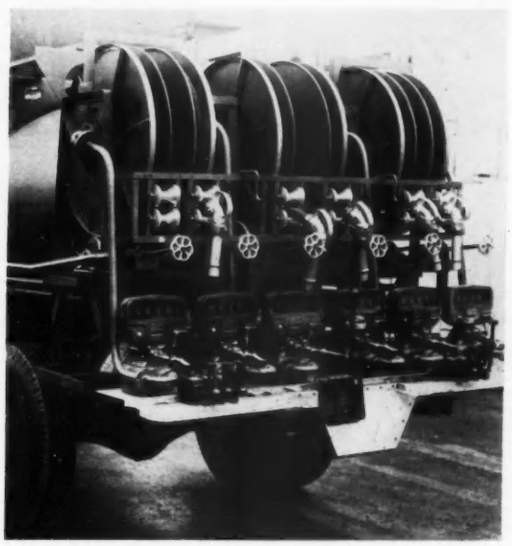
Overhead line crossings of navigable rivers often presented problems in which efficiency, economics and expediency strove with each other for prominence. The width of the river was decided by nature together with not always convenient or picturesque modifications due to man's handiwork. The minimum clearance required between the bottom conductor and high water level was decided by the local river authority, not always with any obvious relation to the top mast heights of ships ever likely to come up river. The Air Ministry might have its own ideas about the maximum height of towers permissible, and entirely local topographical considerations decided whether long approach spans or no approach spans at all could be embodied in the scheme.

An example of a river crossing of more than usual interest was that of the River Orwell at Ipswich. Here, six 132 kV circuits were required. Taking efficiency in its broadest sense the best scheme would have been six single circuit crossings, since lightning would be extremely unlikely to affect more than one circuit at a time. Six crossings would, however, have been far the most costly, far the most unsightly and, in fact, almost impossible owing to restrictions in the selection of tower positions. At the other extreme, a single six-circuit crossing would have been the cheapest in capital costs, but would have meant an intolerable number of eggs in one basket. The arrangement finally adopted was, therefore, two three-circuit crossings, pairs of circuits subsequently continuing as ordinary double-circuit lines being split among the two crossings.

A CLEARANCE PROBLEM

The next problem arose from the fact that the river authorities wanted a minimum clearance to high water of 160 ft., while the Air Ministry was insistent that the overall height to the tops of the towers should not exceed 272 ft. This meant that the conductor sag in the crossing span had to be severely limited in order to comply with the minimum clearance to water. These conflicting requirements, together with the economics of tower design, resulted in the use of a special cadmium-copper conductor. Even then it was necessary to keep the crossing spans as short as possible which meant siting the towers in different positions virtually at the water's edge with correspondingly high foundation costs.

Six grades of lubricating oil can be carried in this tanker, built by Thompson Brothers (Bilston), Ltd. Delivery is by hose, and all controls are grouped at the rear.



The hoses are carried on reels, being run out by hand and returned by power.

DELIVERING LUBRICATING OIL

PRE-SET METERS FOR SIX GRADES

Delivery of lubricating oil to retailers and small consumers is facilitated by a new type of road tanker designed and built by Thompson Brothers (Bilston), Limited, Bilston, Staffordshire, to the requirements of Shell-Mex and B.P. Limited, Shell-Mex House, Strand, London, W.C.2.

The vehicle, which is in appearance similar to other bulk road tankers, is based on a Dennis "Pax" normal-controlled four-wheeled chassis built by Dennis Brothers, Limited, Guildford, Surrey, and powered by a Dennis six-cylinder Diesel engine developing 87 b.h.p. at 2,000 r.p.m. The 900 gallon oil tank, which is fabricated from 14 s.w.g. (0·080 in.) mild steel, is elliptical in shape and is divided into six compartments, three of 200 gallons capacity and three of 100 gallons. Each compartment is provided with a power-driven pump and a pre-set delivery meter, delivery being through flexible hoses. The tank and auxiliary equipment are enclosed by aluminium panelling, which is detachable, and jig-built for interchangeability. At the rear end of the vehicle the panel structure is formed into a single detachable unit, containing a roller shutter which gives access to the controls, meters and hoses. Electric lights are provided at the control points so that the controls can be used during the hours of darkness.

Doors in the panelling give access to side lockers for carrying packaged goods, and there is a folding ladder built into the front nearside panelling; this leads to walkways on the tank top, from which the lids of the six compartments can be reached.

DUPLICATED ENGINE CONTROLS

A Dennis power take-off of the top-drive type provides the drive for the six cargo pumps, which are mounted in a line below the tank, and connected by Layrub couplings. A Hardy-Spicer cardan shaft connects the power take-off with the first pump in the line. Control for the power take-off is grouped with all the other oil-dispensing controls at the rear of the vehicle. Remote hydraulic controls installed by Dennis Brothers, Limited, enable the engine to be started or stopped, the main clutch to be disengaged, the power take-off to be operated, and the engine throttle to be set at the desired running speed from a panel adjacent to the meters and hoses. Full interlocking is provided between the clutch and power take-off, and there is further interlocking between the power take-off and the main gear controls.

The pumps, which are of the double-helical type, supplied by Varley-F.M.C., Limited, Ferry Lane, Brentford, Middlesex, are run at a nominal pumping rate of 12 gallons per minute. Oil flows from the pumps to specially-designed control valves, which allow the oil to circulate freely back to the tank. When the valves are opened they close the compartment-return lines and at the same time act as individual pump pressure relief valves. The valves also form part of a Shell-Mex and B.P. air separator arrangement normally used for lubricating oil deliveries.

PRE-SET METERS

When the pump control valves are opened, the oil pressure generated causes the oil to flow via Brodie-Kent strainers to Brodie-Kent pre-set meters, and thence to the delivery hoses. The meters, supplied by Stemco, Limited, 740 High-road, Tottenham, London, N.17, are of the positive-displacement type, and incorporate a setting mechanism which enables any required quantity of oil to be metered out automatically, the flow ceasing when the pre-set figure is reached. The meter setting range is from 2 to 999 gallons. A seven-figure totalising counter is built into each meter. Any or all of the meters and pumps can be used as required, and it is thus possible to deliver six different grades of oil simultaneously.

Operation of the Brodie-Kent meter is extremely simple. The pre-setting figures are first turned by means of the knob at the side of the meter to indicate the quantity required. The delivery counter is then set to zero by a small lever at the front of the meter, and the meter valve is opened. Delivery commences at once, the pre-set counter moving in reverse towards zero, while the delivery counter moves forward towards the total figure set. The quantity delivered or remaining from the pre-set total can be read at any time while themeter is running. When the pre-set quantity is reached, the meter valve closes automatically, and delivery ceases.

REEL-MOUNTED HOSES

The six Goodyear delivery hoses are each 25 ft. long and of 1 in. bore, and they terminate in specially-designed nozzles which incorporate check valves set to approximately 15 lb. per sq. in. opening pressure. The valves are at the extreme ends of the nozzles, and give "wet hose" conditions, that is, the hose remains filled with oil right up to the nozzle, and there is no need to drain it when pumping ceases. The nozzle ends are designed to be used for open containers or screwed to special containers with closed-type fittings.

Each hose is coiled on a fabricated steel reel, the six reels being mounted co-axially at the rear of the vehicle, just above the meters and controls. The hose reels are normally concealed by the tank casing, only the hose ends and guide rollers being visible, but they are easily accessible when the rear end casing is removed.

To use a hose, it is drawn out by hand to the length required; an enlarged portion engages with the guide rollers at the fully extended position to prevent the hose from being drawn out too far. Reeling-in is by power. A horizontal shaft, mounted below the line of hose reels, is driven through two bevel gearboxes from the last pump in the line, and drive pulleys are keyed on to this shaft in line with one flange of each of the hose reels. To reel in a hose, the appropriate one of six hydraulic master cylinders is operated by means of a hand lever. This moves forward a small friction wheel connected to a hydraulic slave cylinder, and the friction wheel makes contact with both the drive pulley on the shaft and the periphery of the hose reel. The reel then rotates and draws in the hose until the nozzle can be placed on the hook provided, when the friction wheel is released and the drive stops.

★ ★ ★

When proposing the toast of the Institute of Welding, at the annual dinner of the Institute on October 31, the Rt. Hon. R. Maudling, Minister of Supply, referred to the vital importance of technical education in our modern economy. He said that one of the most significant facts at present was the growth of technological education in Russia and the strides also made in this direction by the United States. We as a nation could only maintain our position in competition with our commercial adversaries if we did our utmost to foster and promote the training of engineers and technicians on an increasing scale. The standard of living which had been built up could be preserved only by the quality and scale of our scientific and technical efforts, and our future depended upon our ability to turn our brains, in effect our only raw material, into the goods of commerce.

The Pitzmann and Pfeiffer press.

FOUR-DIRECTION STRAIGHTENING PRESS

The tendency for railways to use longer and longer rails has made straightening of the rail by means of a single-action press extremely difficult. Owing to the heavy weight which has to be handled, turning the rail has become a very hazardous operation. For example, the German Federal Railways now employ standard length of rail 360 ft. long, and to meet this difficulty the German firm of Pitzmann and Pfeiffer, Pforzheim, who have specialised in making hydraulic presses for over a hundred years, and are represented in the United Kingdom by the Embassy Machine and Tool Company, Limited, 248 Watford-way, Hendon, London, N.W.4, have recently developed a hydraulic four-direction straightening press for rails, girders and similar sections.

Basically, the press consists of four sets of pressure cylinders and rams carrying the straightening tools, two cylinders being arranged vertically and two horizontally. Each ram is individually controlled by hand-operated pressure valves, the four valves being grouped in adjacent pairs in a convenient position for the operator. The levers operating the valves are single directional, i.e., when pulling the lever, oil is admitted under pressure to the cylinder; on releasing the lever, the rams return automatically.

The hydraulic power is supplied from a totally-enclosed unit consisting of a hydraulic tank with an immersed variable-pressure pump coupled to a motor. The actual working pressure can be adjusted by means of a control valve and read from an oil-pressure gauge. The maximum pressure which can be exerted by the vertical rams (either from the top or the bottom) is 125 tons, and by the horizontal rams (either front or rear) 65 tons. The maximum operating pressure in the cylinders is 200 atmospheres. The strokes of the vertical and horizontal rams are 115 and 200 mm. respectively. The supports are also adjustable.

Pitzmann and Pfeiffer are at present engaged on the development of an even larger model of the press which will have a vertical straightening force of 200 tons and a horizontal straightening force of 80 tons.

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FLEXIBLE TRANSPARENT DOORS

Doors of flexible transparent plastics for industrial premises are now availale from Superbuilt Products Limited, Bell Works, Harefield, Middlesex. They are claimed to eliminate the danger of accidents associated with the use of the opaque flexible rubber doors now widely used in factories. The Harefield doors are available in sizes up to 8 ft. by 8 ft. wide, and are fitted with double-action tubular hinges.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers and Institution of Engineers-in-Charge

LONDON
"Electronic Control of Industrial Drives," by E. J. P. Long. Annual Joint Lecture Meeting. Magnet House, Kingsway, London, W.C.2. Tues., Nov. 13, 6.30 p.m.*

Association of Supervising Electrical Engineers

LONDON
"Interplanetary Science and the Development of the Rocket," by K. L. Ward. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Nov. 12, 7.30 p.m.

BOURNEMOUTH
"Lighting," by R. T. O'Freeth. Bournemouth Branch. Grand Hotel, Firvale-road, Bournemouth. Tues., Nov. 13, 8 p.m.

GLASGOW
"Fire Protection," by A. Chadwick. Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Nov. 14, 8 p.m.

SOUTHAMPTON
"Transistors and Their Applications," by R. R. Betteridge. Southampton Branch. Polygon Hotel, Southampton. Thurs., Nov. 15, 8 p.m.

British Institution of Radio Engineers

NEWCASTLE-UPON-TYNE
"Practical Aspects of Echo Sounding," by A. M. Sutton. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Nov. 14, 6 p.m.

WOLVERHAMPTON
"The Automatic Foundry," by J. A. Sargrove. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Nov. 14, 7.15 p.m.

Building Centre

LONDON
Films on "Bright New World" and "Living with Formica," exhibited by Thos. De La Rue & Co. Ltd. Wed., Nov. 14. 12.45 p.m.

Chemical Engineering Group

LONDON
"Manufacture of Phthalic Anhydride by the Fluidised-Catalyst Method," by H. L. Riley. The Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., Nov. 13, 5.30 p.m.

Chemical Society

LONDON
Various papers. Special meeting to commemorate 70th birthday of Sir Ian Heilbron. Thurs., Nov. 15, 7.30 p.m.

CAMBRIDGE
"Solutions in Sulphuric Acid," by Dr. R. J. Gillespie. Cambridge Branch. University Chemical Laboratory, Lensfield-road, Cambridge. Fri., Nov. 16, 8.30 p.m.

DURHAM
"Organic Semi-Conductors," by Professor D. D. Eley. Newcastle and Durham Branch. Science Laboratories, The University, Durham. Mon., Nov. 12, 5.15 p.m.

MANCHESTER
"Recent X-Ray Structural Determinations in Glasgow," by Prof. J. M. Robertson. Manchester Branch. College of Technology, Manchester. Wed., Nov. 14, 6.30 p.m.

Illuminating Engineering Society

LONDON
"Starting Fluorescent Lamps," by D. T. Waigh and L. C. Wiltshire. Federation of British Industries, 21 Tothill-street, S.W.1. Tues., Nov. 13, 6 p.m.

SHEFFIELD
"Trends in Interior Installations and Designs," by H. H. Ballin. Sheffield Centre. Medical Library, The University, Western Bank, Sheffield 10. Mon., Nov. 12, 6.30 p.m.

Incorporated Plant Engineers

BLACKBURN
"Smoke Abatement—Part II," by J. D. Lewis. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Nov. 15, 7.30 p.m.

BRISTOL
"Materials Handling," by J. G. Parkes. Western Branch. Grand Hotel, Bristol. Wed., Nov. 14, 7.15 p.m.

DUNDEE
"Maintenance of Gas Turbine Aircraft Engines in the Royal Air Force," by Squadron Leader D. J. Hughes. Dundee Branch. Mathers Hotel, Dundee. Mon., Nov. 12, 7.30 p.m.

MANCHESTER
"Lubrication and the Selection of Lubricants," by G. Stott. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., Nov. 13, 7.15 p.m.

NOTTINGHAM
"Engineering Equipment in Modern Buildings," by G. W. Glover. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Nov. 14, 7 p.m.

Institute of British Foundrymen

BRISTOL
"Modern Casting Design and Running Technique," by R. W. Ruddle. Bristol and West of England Branch. Grand Hotel, Bristol. Sat., Nov. 17, 3 p.m.

Institute of Marine Engineers

LONDON
"Reheating as a Contribution to the Economy of the Marine Steam Turbine, with Special Reference to the Installation in the T.S.S. Empress of Britain," by A. W. Davis. Tues., Nov. 13, 5.30 p.m.*

BOLTON
"Marine Diesel Engines," by A. G. Arnold, presented by E. Perry. Junior Lecture. Merseyside and North Western Section. Technical College, Bolton. Wed., Nov. 14, 2.30 p.m.

GLASGOW
"Balancing of Marine Reciprocating Engines," by B. Hildrex. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Nov. 14, 7.30 p.m.

Institute of Metals

SWANSEA
"Fuel," by C. A. J. Plummer. South Wales Local Section. Electricity Showrooms, Kingsway, Swansea. Tues., Nov. 13, 6.45 p.m.

Institute of Road Transport Engineers

LONDON
"Current Trends in Fuel Injection Equipment for Road Transport," by J. Skinner. Royal Society of Arts, John Adam-street, W.C.2. Thurs., Nov. 15, 6.30 p.m.

LEEDS
"Application of Arc Welding to Road Transport Vehicles," by J. K. Johannesen. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds, 1. Thurs., Nov. 15, 7.30 p.m.

MANCHESTER
"Development and Operation of Disc Brakes," by T. J. Phipps. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., Nov. 12, 7.30 p.m.

PRESTON
"Tyre Requirements for Modern Commercial and Public Service Vehicles," by W. Humphries. North Regional Centre. Victoria and Station Hotel, Preston. Tues., Nov. 13, 7.30 p.m.

Institution of British Agricultural Engineers

LONDON
"Mechanical Properties of Soil in Relation to Basic Cultivation," by Dr. P. Payne. Tues., Nov. 13, 5.30 p.m.*

BRISTOL
"Economics of Rural Electrification," by W. J. Guscott; and "Electric Motors on the Farm," by B. Stocks. Western Centre. Electricity House, Bristol. Mon., Nov. 12, 7.15 p.m.

NEWCASTLE-UPON-TYNE
"Design of Agricultural Tyres and Other Uses of Rubber in Agriculture," by B. W. D. Lacey. Northern Centre. Offices of the North Eastern Electricity Board, Carliol House, Newcastle-upon-Tyne. Mon., Nov. 12, 6.45 p.m.

Institution of Chemical Engineers

MANCHESTER
"Animal Foodstuff Plant: Some Considerations," by H. Holdsworth. North Western Branch. College of Technology, Manchester. Sat., Nov. 10, 3 p.m.

Institution of Civil Engineers

LONDON
"Effect of Synthetic Detergents on the Biological Oxidation of Sewage," by L. Barden and P. C. G. Isaac. Public Health Division. Tues., Nov. 13, 5.30 p.m.*
"Conservation of Natural Resources." IV—"Metallic Corrosion and Conservation," by W. H. J. Vernon. Thurs., Nov. 15, 5.30 p.m.*

HULL
"Law of Contract," by A. H. Hudson; and "Application of Contract Law to Civil Engineering," by R. K. Conway. Yorkshire Association. Electricity Building, Ferensway, Hull. Thurs., Nov. 15, 6.15 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "Power Factor in Industrial Installations,"

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.E.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

opened by C. F. Freeman. Informal Meeting. Mon., Nov. 12, 5.30 p.m.*
"Digital Computers and How They May Help the Engineer," by Dr. M. V. Wilkes. London Graduate and Student Section. Tues., Nov. 13, 6.30 p.m.*
Various short papers. Radio and Telecommunication Section. Wed., Nov. 14, 5.30 p.m.*
"A Self-Oscillating Induction Motor for Shuttle Propulsion," by E. R. Laithwaite and P. J. Lawrenson; and "Brushless Variable-Speed Induction Motors," by Professor F. C. Williams, E. R. Laithwaite and L. S. Piggott. Utilization Section. Thurs., Nov. 15, 5.30 p.m.*
BELFAST
"Highland Water Power: Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie. Northern Ireland Centre. Engineering Department, Queen's University, Belfast. Tues., Nov. 13, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Control and Instrumentation of a Nuclear Reactor," by A. B. Gillespie. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Nov. 12, 6.15 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Equipment and Operation of a Small Heating and Ventilating Test Laboratory," by F. R. L. White. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Tues., Nov. 13, 6.30 p.m.
CARDIFF
"Ventilation and Plenum Design," by N. F. Parry. South Western Branch. G.E.C. Building, Cardiff. Tues., Nov. 13, 6.30 p.m.
MANCHESTER
"Water Treatment for Small Steam Boilers," by A. J. Rogers. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Nov. 16, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Five papers on "Research in Automobile Stability and Control," by authors from the Cornell Aeronautical Laboratory, U.S.A. Automobile Division. Tues., Nov. 13, 4.30 p.m.* Discussion on "Are Diesel Engines an Interim Phase in Rail and Road Transport Development?" Internal Combustion Engine Group. Thurs., Nov. 15, 5.45 p.m.*
"Simulated Gear Tooth Contacts: Some Experiments upon Their Lubrication and Subsurface Deformations," by Dr. A. W. Crook. Meeting in conjunction with the Applied Mechanics and Lubrication Groups. Fri., Nov. 16, 6 p.m.*
COVENTRY
Five U.S. papers on "Research in Automobile Stability and Control." Birmingham and Coventry A.D. Centres. St. Mary's Hall, Coventry. Thurs., Nov. 15, 6.30 p.m.
MIDDLESBROUGH
"Pumping Problems: Present and Future," by H. Addison. North Eastern Branch. Cleveland Scientific and Technical Institute, Middlesbrough. Wed., Nov. 14, 6.15 p.m.
SOUTHAMPTON
"Steam Cycles and Nuclear Power Plant," by R. E. Zoller. Southern Branch. Polygon Hotel, Southampton. Wed., Nov. 14, 7 p.m.

Institution of Mining and Metallurgy

LONDON
"A New Process for Pneumatic Stowing: Its Development and Introduction at the Rio Tinto Mines, Spain," by Edward Rich; and "Developments in Tailing Disposal at Roan Antelope Copper Mines, Northern Rhodesia," by M. R. Goldick. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Nov. 15, 5 p.m.*

Institution of Production Engineers

LONDON
"Automation for Batch Production," by Ian Nickols. Royal Empire Society, Craven-street entrance, W.C.2. Thurs., Nov. 15, 7 p.m.
DONCASTER
"Copying Devices and Tracer Controlled Machine Tools," by H. C. Town. Doncaster Section. Danum Hotel, Doncaster. Tues., Nov. 13, 7 p.m.
GLASGOW
"Electro-Spark Machining," by G. Fefer. Glasgow Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Nov. 15, 7.30 p.m.

Institution of Public Health Engineers

LONDON
"Control and Treatment of Industrial Wastes," by W. Fillingham Brown. Public Works Congress, Olympia, W.14. Mon., Nov. 12, 3 p.m.

Institution of Structural Engineers

GLASGOW
"Tubular Structures," by R. G. Taylor. Scottish Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Tues., Nov. 13, 7 p.m.

Junior Institution of Engineers

LONDON
"Semi-Conductors and Their Applications," by R. A. Hill. Fri., Nov. 16, 7 p.m.*
SHEFFIELD
Presidential Address on "Civil Maintenance and Organisation for the R.A.F. in India During World War II," by J. N. Compton. Sheffield Section. 44 Union-street, Sheffield, 1. Mon. Nov. 12, 7.30 p.m.

Liverpool Engineering Society

LIVERPOOL
"Experience with the Heat Pump in Great Britain," by Miss M. V. Griffiths. Wed., Nov. 14, 6 p.m.

Newcomen Society

LONDON
"Norfolk Windmills: Part II, Drainage Mills," by Rex Wailes. Annual General Meeting. Wed., Nov. 14, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Some Safety Considerations of Nuclear Power Reactors," by C. D. Boadle. Mining Institute, Newcastle-upon-Tyne. Fri., Nov. 16, 6.15 p.m.

Reinforced Concrete Association

LONDON
"Manufacture of Hollow Reinforced Concrete Beams (Dow-Mac Process)," by W. K. Roberts. 11 Upper Belgrave-street, S.W.1. Wed., Nov. 14, 6 p.m.*

Royal Aeronautical Society

LONDON
"Air Conditioning of Aircraft," by Dr. E. W. Still. Tues., Nov. 13, 7 p.m.

Royal Institution

LONDON
"Roman Military Engineering," by Professor I. A. Richmond. Fri., Nov. 16, 9 p.m.

Royal Statistical Society

BRISTOL
"How Statistics Can Help Technical Investigations in the Factory," by L. H. C. Tippett. Bristol Study Group. The University, Bristol, 8. Thurs., Nov. 15, 5.45 p.m.*

Royal United Service Institution

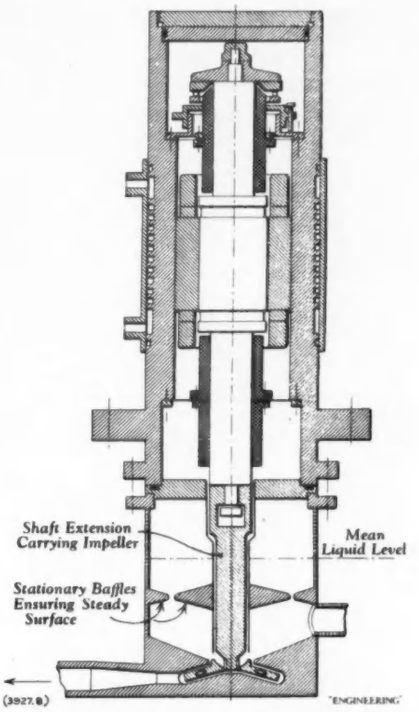
LONDON
"Oil in the Middle East," by R. G. Searight. Tues., Nov. 13, 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Properties of High Melting Point Metals," by Dr. L. Northcott. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Nov. 13, 7 p.m.

Women's Engineering Society

LONDON
"Engineering Training," by R. G. Bellamy, Miss P. J. Wilson and Miss A. R. Chamney. London Branch. Hope House, 45 Great Peter-street, S.W.1. Wed., Nov. 14, 7 p.m.*



Molten-bismuth pump, as may be used in future reactors, where bismuth may serve as carrier fluid for the fuel. The performance of gas bearings improves with increasing temperature.

ATOMIC REVIEW

Heat Output of Nuclear Fuel

Calculating the coal and thermal equivalents of uranium fuel: (1) *theoretically feasible output;* (2) *output achieved at present; and* (3) *output which may be obtained in the near future by breeding—Gas lubricated bearings as applied to* (1) *gas circulators and* (2) *molten-metal pumps.*

The fundamental consideration in determining the output of a nuclear reactor is the heat available from a given quantity of nuclear fuel. This problem is discussed in a United Kingdom Atomic Energy Authority technical information sheet, in which the output obtained at present and the feasible output are compared. The calculation is as follows.

Natural uranium consists substantially of 1 part by weight of uranium 235 and 140 parts of uranium 238, and in nuclear reactions involving natural uranium and slow neutrons, it is the atoms of the lighter isotope that usually undergo fission. When a uranium 235 atom is split after absorbing a neutron the nuclear reaction may be, for example:

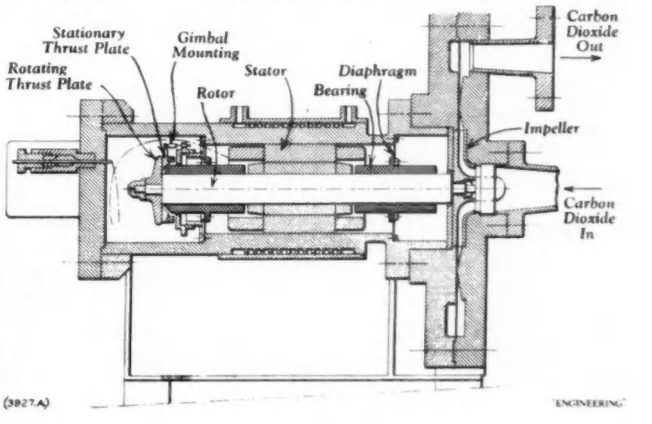
$$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236} \rightarrow {}_{57}La^{148} + {}_{35}Br^{85} + 3{}_{0}n^{1}$$

and the mass equation:

$$235{\cdot}124 + 1{\cdot}009 \rightarrow 147{\cdot}961 + 84{\cdot}938 + 3{\cdot}027,$$

where n represents a neutron, the subscripts indicate the atomic number of the nucleus, that is the number of protons, and the superscripts the mass number or total number of neutrons plus protons. The letters are the normal symbols for the chemical elements.

The mass sum is: LHS = 236·133
RHS = 235·926
The difference in mass = 0·207 units.



Carbon dioxide circulator employing gas lubricated bearings. In closed gas systems such as the coolant circuit of a gas-cooled reactor, conventional lubricants may be excluded on grounds of inaccessibility or contamination.

This appears as energy equivalent to 0·207 × 931 = 193 MeV, or approximately 200 MeV.

Now 1 MeV = 1·60 × 10^{-6} erg. So 200 MeV, the energy from 1 split uranium 235 atom = 320 × 10^{-6} erg. = 3·20 × 10^{-11} watt-sec., that is, it requires 3·1 × 10^{10} fissions per sec. to produce 1 watt.

In 1 lb. of uranium 235 there are:

$$\frac{453{\cdot}6}{235{\cdot}124} \times 6{\cdot}023 \times 10^{23} = 11{\cdot}62 \times 10^{23} \text{ atoms.}$$

Hence if all the atoms in 1 lb. of uranium 235 underwent fission, the energy released would be 11·62 × 10^{23} × 3·20 × 10^{-11} watt sec. = 37·2 × 10^{12} watt sec. = 10·32 million kWh.

Alternatively, if 1 lb. of uranium 235 were fissioned at the rate of 3·1 × 10^{10} fissions per sec. we should get power at the rate of 1 watt for 1·032 × 10^{10} hours.

Similarly, 3·1 × 10^{13} fissions per sec. would give 1 kW for 1·032 × 10^{7} hours and 3·1 × 10^{16} fissions per second would give 1 MW for 1·032 × 10^{4} hours.

One kilowatt-hour is equivalent to 3,413 B.Th.U. Hence the energy released by fissioning all the atoms in 1 lb. of uranium 235 =

$10{\cdot}32 \times 10^6 \times 3{,}413$ B.Th.U. Thus, if the calorific value of coal is 12,000 B.Th.U. per lb. and if all the atoms in 1 lb. are fissioned, 1 lb. of uranium 235 is equivalent to $\frac{10{\cdot}32 \times 10^6 \times 3{,}413}{12{,}000}$ = approximately 3,000,000 lb. of coal; or 1 ton of uranium 235 is equivalent to 3,000,000 tons of coal.

There are slightly fewer atoms in 1 lb. of natural uranium than there are in 1 lb. of uranium 235. However, the difference is small, so that if all the atoms in 1 lb. of natural uranium could be split then 1 lb. of natural uranium would also release as much heat energy as 3,000,000 lb. of coal.

The complete fissioning of all the atoms in 1 gram of uranium 235 will release

$$\frac{3{\cdot}20 \times 10^{-11} \times 6{\cdot}023 \times 10^{23}}{235{\cdot}124} = 8{\cdot}2 \times 10^{10} \text{ watt-secs.}$$

$$= \frac{8{\cdot}2 \times 10^{10}}{3{,}600 \times 1{,}000} \text{ kWh}$$

$$= 2{\cdot}3 \times 10^4 \text{ kWh}$$

$$= 1 \text{ MWD (approx.)}$$

or 1 gram of uranium 235 fissioned per day give approximatelv 1 MW.

The uranium 235 content of 1 tonne of natural uranium is 7,000 grams. Therefore, if just under half the uranium 235 content of 1 tonne of natural uranium is fissioned we would get about 3,000 MWD of energy released.

Alternatively: at present only about half the readily fissionable kind of uranium atoms, the uranium 235 that occurs to the extent of 1 part in 140 of natural uranium, can be split. Hence, at present 1 lb. of natural uranium will only release as much heat energy as $\frac{3{,}000{,}000}{140 \times 2}$ = approximately 10,000 lb. of coal, that is, 3,000 MWD per tonne. The reason that only such a low conversion factor can be realised at present is because atomic residues or fission products accumulate in the fuel rods and eventually stop the reaction.

When natural uranium is used in a Calder Hall type reactor, some of the neutrons (one in every fission) released in a fission reaction are used to carry on the chain reaction. The others either escape or are absorbed by the unfissionable atoms, uranium 238, and convert it eventually into plutonium, a new element that is also fissionable. If the spent fuel rods are processed and the fission products and the plutonium formed separated, the plutonium being again used in the same reactor, it is estimated that over 1 per cent. of the natural uranium can be burnt. In this case 1 lb. of natural uranium will be equivalent to 30,000 lb. of coal.

To approach the theoretically complete burn-up of all the atoms in 1 lb. of uranium, that is, 1 lb. uranium = 3,000,000 lb. of coal = 1 million MWD per tonne, use will have to be made of breeder reactors in which more fuel is produced from fertile material than is burnt. To illustrate this, supposing 1,000 lb. of natural uranium were taken and separated into its two component kinds of atom, we should then have 7 lb. of uranium 235 and 993 lb. of uranium 238. If the nuclear reaction were started in the 7 lb. of uranium 235, for every uranium 235 atom split, on average 2½ fresh neutrons would be produced. One of these would be required for carrying on the reaction and 1½ would be spare. If the 993 lb. of uranium 238 were stacked round the reacting core of uranium 235 the 1½ spare neutrons from the fission could be absorbed in the uranium 238 blanket where they would produce 1½ atoms of plutonium for every atom of uranium 235 split. When all the 7 lb. of uranium 235 had been consumed we should be left with a mass of 982½ lb. of uranium 238 containing 10½ lb. of plutonium. After separating the plutonium from the uranium 238 we could then start a new reaction with the 10½ lb. of plutonium, stack round it the 982½ lb. and produce a further 16 lb. of plutonium. Thus we could continue until all the original 1,000 lb. of natural uranium had been split to give the equivalent of 3,000,000 lb. of coal for each pound of uranium. Due to losses in processing and other causes, it is not likely that it will be possible to burn all the uranium, but figures of 1 lb. of uranium equivalent to 30,000 or 60,000 lb. of coal should be soon available. A figure of 1 lb. of uranium equivalent to 1,000,000 lb. of coal should be attainable later.

Gas Lubricated Bearings

The development of a new branch of engineering calls at first for the establishment of general principles, but later it becomes necessary to attack specific problems and to consider items of equipment in detail. Clearly, much work of this kind has already been carried out, since otherwise the construction of a station such as that at Calder Hall would be impossible; however, little of a direct engineering nature concerning the application of atomic energy has so far been published. A paper delivered recently before the Institution of Mechanical Engineers dealt with a practical design problem which, though of general application, is of special significance in the field of nuclear engineering. The paper, presented by Mr. G. W. K. Ford, M.B.E., Mr. D. M. Harris and Mr. D. Pantall, had as its title: "Principles and Applications of Hydrodynamic-Type Gas Lubricated Bearings." A shortened version of the paper appeared last week on page 559.

The call for gas-lubricated bearings arose from the need to install moving parts within enclosed gas circuits, possibly at high pressures and temperatures, where contamination of the gas is undesirable, the parts themselves are largely inaccessible and the formation of oxide films impossible. This occurs in gas-cooled reactors such as those at Calder Hall, and an illustration on the previous page shows a carbon-dioxide circulator employing gas bearings. Another application may be in future reactors where it is necessary to pump liquid metals, probably at high temperatures, so that a lubricant is required that does not deteriorate under the action of heat, and will not contaminate the metals being pumped. The pumping of bismuth, which may serve as solvent for the fuel of certain advanced reactors, is considered by the authors, and another illustration on page 603 shows in section a pump for molten bismuth using gas bearings.

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THERMAL STORAGE

Meeting Fluctuating Demands for Steam

Wherever the demand for steam is not constant, there arises the problem of varying the rate of stoking to suit the change. This can lead to inefficient operation and waste of fuel. A special type of Economic boiler has now been developed, however, to cope with precisely this problem. Based on patents held by Dr. E. Y. Ritchie, the boiler is made by Edwin Danks and Company (Oldbury), Limited, Oldbury, near Birmingham.

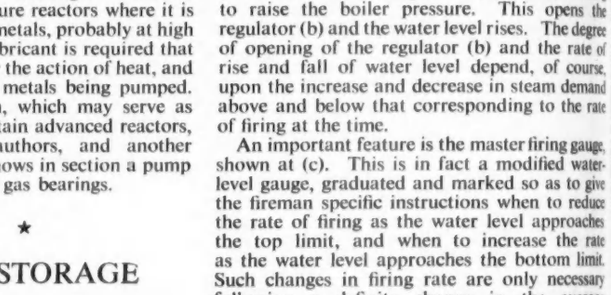
The storage action of the boiler is based on using the water volume as what might be termed a "thermal flywheel." Heat is stored by a controlled rise in water level during periods of low steam demand, and released by allowing the level to fall at peak periods. In order to provide substantial storage capacity the shell is enlarged in diameter compared with a normal boiler, to enable a safe rise and fall of water level of 2 ft. to 3 ft. to be obtained.

With this boiler peaks of 25 to 40 per cent. above the average steam demand (depending upon the difference in temperature between the water in the hotwell and the water in the boiler) and valleys of commensurate magnitude, can be met without change in process steam pressure and without change in firing rate. (Stored feed water in the boiler absorbs its sensible heat up to saturation temperature and acts as a heat consumer, which is brought "on the line" or taken "off the line" automatically, depending upon the variation in the steam demand of the factory.)

In addition to providing coverage for peaks and valleys by rise and fall of water level, the thermal storage boiler is generally designed for a working pressure higher than is required in the factory, and short sharp peaks beyond the control of feed-water storage alone are met by limited boiler pressure variation, a steam pressure regulator being interposed between the boiler and the factory to ensure the maintenance of a constant steam pressure.

Diagrammatic details are shown in the illustration. The regulator (a), located in the steam main, automatically maintains a constant steam pressure on the factory supply, while the regulator (b), governed from the boiler header, controls the flow of feed water to the boiler. With an increase in steam demand, the regulator (a) opens, tending to lower the boiler pressure; this causes the regulator (b) to close, and the water level drops. With the occurrence of a fall in the steam demand, the regulator (a) closes, tending to raise the boiler pressure. This opens the regulator (b) and the water level rises. The degree of opening of the regulator (b) and the rate of rise and fall of water level depend, of course, upon the increase and decrease in steam demand above and below that corresponding to the rate of firing at the time.

An important feature is the master firing gauge, shown at (c). This is in fact a modified water-level gauge, graduated and marked so as to give the fireman specific instructions when to reduce the rate of firing as the water level approaches the top limit, and when to increase the rate as the water level approaches the bottom limit. Such changes in firing rate are only necessary following a definite change in the average steam demand, as, for example, a change from day load conditions to night load conditions, and this can be brought about slowly without sacrificing efficiency. If the fireman fails to take action at the proper time, high or low water level over-controls come into operation and audible alarms are sounded. As long as the water level remains in the section of the master firing gauge marked "Constant," no change of firing rate is required. This leaves the fireman plenty of time for the proper adjustment of fans, dampers and other items, in the interest of high combustion efficiency. The system is quite capable of meeting changes in demand where the maximum is twice the minimum.



As demand fluctuates, the steam-pressure regulator opens or closes and controls the feed-water regulator, allowing the water level to rise or fall. Changes in demand of ± 40 per cent. can be met in this way without altering the rate of firing.

In Parliament

WIDE RESEARCH ON FUELS

A question by Mr. Ian Mikardo (Labour) to the Minister of Fuel and Power last week called attention to the number of organisations at present engaged on fuel research. He was informed by Mr. Aubrey Jones that the major research bodies engaged mainly on problems connected with fuel were the Ministry of Fuel and Power, Department of Scientific and Industrial Research, National Coal Board, Central Electricity Authority, Gas Council, British Coal Utilisation Research Association, British Coke Research Association, British Electrical and Allied Industries Research Association, and the Coal Tar Research Association. The research budgets for these organisations amounted to £3,250,000 for the financial year 1954-55.

Co-ordination between the work of the two Government Departments mentioned and of the three nationalised industries was secured through frequent consultation and through the examination of their research programmes by the Scientific Advisory Council of the Fuel Ministry, upon which all the bodies mentioned were represented. Research associations sponsored by the Government were autonomous organisations whose programmes were determined by their respective councils; but these, too, contained representatives of the Government Departments and nationalised industries concerned.

As far as oil research was concerned, Mr. Jones said, the Scientific Advisory Council included a distinguished oil scientist and, from time to time, the principal oil companies were invited to furnish qualitative statements respecting their research work, in cases where this work did not vitally affect their competitive positions.

MAJOR ROAD PROJECTS

Particulars were given by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, of five road projects to which he attached special importance. First, there was the improved trunk road from London to the north-east, based on the present Great North Road, and, secondly, a new motor road from London to the north-west, the first part of which would be the motor road from North London to the south-east of Birmingham. It was hoped to complete this section by 1960.

Thirdly, there were to be improvements to the two existing trunk roads from London to the south-east, by-passing the Medway towns (A2) and Maidstone and Ashford (A20). Fourthly, there was to be a road from the Midlands to South Wales, including the new Ross Spur motor road from Upton-on-Severn to Ross and substantial reconstruction of the existing Heads of the Valleys Road between Abergavenny and Hirwaun. Lastly, there was the road from London westwards to London Airport, the West of England and South Wales.

The Minister informed Mr. Ernest Davies (Labour) that, in so far as they were not already included in the Ministry's road programme, these schemes would be added as soon as the country's economic and financial position allowed sufficient funds to be devoted to road purposes.

FORTH CROSSING PROBLEM

Proposals have been made by the Government to the Joint Board for the financing of the Forth road bridge. In this connection, Mr. J. Stuart, the Secretary of State for Scotland, told the House that he understood that the Joint Board had agreed, at their meeting last week, to recommend to their constituent authorities that an amending Order should be prepared to give effect to these proposals.

It was suggested that the constituent authorities and the Government should contribute the sums of £500,000 and £4,650,000, respectively, referred to in the Order of 1947, and that the remaining part of the cost should be met in the first place from loans advanced to the Joint Board by the Government. These loans would then be repayable from the proceeds of tolls. The proposals had been put forward subject to agreement being reached in respect of suggestions on other aspects of the scheme and on estimates of costs.

The Minister told Sir Ian Clark Hutchison (Conservative) that he expected to receive a report on the technical discussions regarding the scheme in the very near future.

British Air Services to Eire

In answer to questions by Mr. Cledwyn Hughes (Labour), Mr. Harold Watkinson stated that, as announced early in September, agreement had now been reached with the Government of the Irish Republic on the revision of the Air Services Agreement with that country, signed in 1946. As a result, British European Airways and some independent companies would be able, for the first time since World War II, to operate scheduled services to and from the Irish Republic.

United Kingdom airlines would be able to operate services on three new routes between Wales and Eire, and to supplement the existing service of Aer Lingus on the Cardiff-Dublin route. The new routes would be Haverfordwest-Dublin, Cardiff-Cork, and Haverfordwest-Cork; but the introduction of the services to Cork would have to await the construction of a new aerodrome there. The full text of the exchange of letters between the two Governments, which brought the revised agreement into force, would be published shortly as a Command Paper by H.M. Stationery Office.

Overloading of Shipping

Mr. M. Turner-Samuels (Labour) drew the attention of the Minister of Transport and Civil Aviation to the observations of Mr. Justice Devlin in the recent case of *St. John Shipping Corporation* versus *Joseph Rank Limited*, namely, that section 44 of the Merchant Shipping (Safety and Load-Line Conventions) Act, 1932, which imposes a fine of £100 for every inch by which the load-line was submerged, might now be of little or no value as a deterrent. He also pointed out that, while a British master was liable to imprisonment for an offence under this section of the Act, a foreign master was not, and he suggested that legislation should be introduced to amend the section so as to remedy it in both these respects.

In his reply, Mr. Watkinson said he had every sympathy with the suggestion for increasing the fines which could be imposed for overloading. The matter had been noted for amending legislation when a suitable opportunity presented itself. To make foreign masters liable to imprisonment was a more difficult problem and one which might create undesirable results for British masters abroad.

Wear and Tear on Ships

Mr. John M. Howard (Conservative) urged the Chancellor of the Exchequer to give further consideration to the provision of additional allowances to cover the increased cost of shipping, on the condition that the gross amount of such additional allowances be deposited with the Treasury and released at the time when the replacements occurred. Mr. Henry Brooke, the Treasury's Financial Secretary, replied that the Chancellor was giving close attention to the taxation position of the shipping industry. There were objections to Mr. Howard's suggestion, but his proposal would certainly be borne in mind.

Nuclear Power Stations in Scotland

Asked by Mr. Hector Hughes (Labour) about the Government's plans for the further development of nuclear power in Scotland, for industrial and domestic purposes, Mr. J. Stuart said that, apart from electricity to be supplied from the United Kingdom Atomic Energy Authority's Scottish establishments, this matter was primarily the responsibility of the Scottish electricity boards. In this connection the South of Scotland Electricity Board had applied for his consent to the construction of a nuclear power station in Ayrshire.

Commonwealth Sources of Uranium

A mining company has been granted a concession to prospect for radioactive minerals in the Tambini area of Nyasaland, Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, told Mr. George Craddock (Labour). It was, however, too early at present to indicate whether the occurrence of these minerals would be large enough to warrant their development on a commercial scale.

Policy on Overseas Trade Fairs

Mr. Peter Thorneycroft, the President of the Board of Trade, informed the House that he had set up a committee to advise him regarding any changes that might be necessary respecting the policy of his Department towards overseas trade fairs and exhibitions. The Minister of State to the Board, Mr. A. R. W. Low, was acting as chairman, and the other members were Mr. R. P. S. Bache, Mr. J. E. C. Bailey, Mr. W. B. Beard, C.B.E., Sir Ernest W. Goodale, C.B.E., Mr. John McLean, C.B.E., Mr. F. Rostron, Sir Cecil Weir, K.C.M.G., and Dr. W. J. Worboys. In addition, the Foreign Office, the Commonwealth Relations Office and the Board of Trade were represented by senior officials. Mr. Thorneycroft told Mr. J. A. Leavey (Conservative), who raised the matter, that the first meeting of the committee had already been held.

Iron for Rural Craftsmen

The President of the Board of Trade was also asked whether he had been able to improve supplies of iron and mild steel to rural craftsmen, in view of the consultations taking place between the Iron and Steel Board, the British Iron and Steel Federation, and the National Association of Iron and Steel Holders. The Board's Minister of State, Mr. A. R. W. Low, told Mr. Marcus Kimball (Conservative) that the inquiry was not yet complete. He understood, however, that there had been a further increase in the total supplies of the small sizes of iron and steel which were normally used by rural craftsmen.

American Aircraft for B.O.A.C.

Some further information respecting the Government's approval of the proposals of the British Overseas Airways Corporation to purchase Boeing jet aircraft from the United States was disclosed in an answer to Mr. Frank Beswick (Labour-Cooperative). He was informed by Mr. Watkinson that the question of import duties on these aircraft and the relevant spare parts did not arise at this stage. Further, this type of aircraft had not yet obtained a British certificate of airworthiness.

Hawker Fighter Aircraft Project

Information was sought by Mr. John E. Harvey (Conservative) from the Minister of Supply as to what public money had been spent on the new Hawker super jet fighter on which work had been recently stopped. Mr. Reginald Maudling told him that reports in the Press that work on a Hawker fighter had recently been stopped were incorrect. The Hawker Company had been developing a fighter aircraft of advanced design as a private venture and he understood that work on the project was continuing. No public money, however, had been expended on it.

New Dockyard Technical College?

Mr. A. G. Bottomley (Labour) asked the Parliamentary Secretary to the Admiralty for a further statement about the future of the Royal Marine Barracks at Chatham. In reply, Mr. S. Wingfield Digby, the Civil Lord of the Admiralty, said it was hoped that the site on which those buildings now stood could be used for a new combined dockyard technical college and apprentices' training centre. There was a proposal to provide funds in the coming financial year for the necessary design work and for the preparation of detailed plans.

A model of a proposed multi-storey car park for London. A dolly built into the lift is used for transferring the car between the lift and the parking stall.

AUTOMATIC CAR PARKS

A new development in car parks, described by its designers, Griggs Rotapark, 56 Victoria-street, London, S.W.1, as a fully-automatic parking machine, has been proposed by Lex Garages Limited, 2 Lexington-street, London, W.1, as a step owards solving parking congestion in the City of London, and is now under consideration by the city authorities and the London County Council. If the scheme is approved, construction will go forward on a site in Great Queen-street.

As shown in the accompanying illustrations, the Rotapark has up to ten storeys comprising rotary platforms each arranged with 32 radial stalls to receive the cars, which are handled by four lifts each serving a 90 deg. quadrant of the parking space. The platforms would normally swing over a 90 deg. arc only, but they can move through a full circle in the event of a lift failure. This makes for an extremely compact park. A ten-storey unit 90 ft. high can house 320 cars, plus 30 in a " reservoir " on the ground floor, yet requires a space of only 100 ft. square.

The lift and rotor mechanisms for parking the cars may either be push-button operated by one of two operators, each of whom looks after two of the four lifts, or they may be actuated completely automatically by an electronic control unit monitored from a central control office. The proposed Lex installations envisage electronic control, and will operate as follows:—the car driver, on entering the ground-floor " reservoir," will be handed a punched disc, indicating the car stall and the lift to be used. He drives to the appropriate lift, and parks the car, with brakes off, on a turntable in front of the lift. The driver, on leaving the car, inserts the punched disc in a mechanism at the lift entrance, causing the control unit to actuate the " parking machine " in the correct sequence.

The turntable automatically aligns the car with a universal parking " dolly " suitable for handling any make of car and built integrally with the lift, which is normally stationed at ground-floor level. The dolly advances and engages with the car behind the front wheels; it then retracts, pulling the car on to the lift platform. The rotary platform on the appropriate storey has meanwhile been driven round to bring the pre-selected parking stall opposite the lift entrance. The lift ascends and on reaching its destination the automatic dolly transfers the car into its stall and retracts, and the lift descends again. Retrieval of parked cars is carried out in a reverse manner, the central control office in this case initiating the action when the customer has paid his bill. The time taken per car movement is claimed to be less than one minute.

Ground - floor plan of proposed Rotapark for Great Queen-street, London. The car is parked on one of the four turntables which automatically aligns it with a lift, elevating it to one of ten rotating parking platforms.

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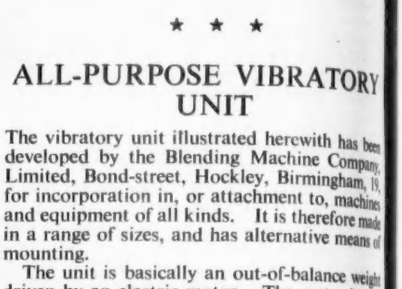
ALL-PURPOSE VIBRATORY UNIT

The vibratory unit illustrated herewith has been developed by the Blending Machine Company, Limited, Bond-street, Hockley, Birmingham, 19, for incorporation in, or attachment to, machines and equipment of all kinds. It is therefore made in a range of sizes, and has alternative means of mounting.

The unit is basically an out-of-balance weight driven by an electric motor. The motor is continuously rated, and as the complete unit is built into a totally-enclosed housing, it is impervious to moisture and dust. The size range is 40, 60, 80, 160, 250, 500 and 800 watts,



Totally enclosed and continuously rated, this vibratory unit is available in a range of sizes. Alternative means of mounting are available, and the periodicity and amplitude can be varied within fairly wide limits.

and the motor can be wound to suit any specified alternating-current supply.

Mounting is by means of the side lugs shown in the illustration; alternatively, the unit can be supplied with a base-type mounting with slots instead of bolt holes, for easy installation and removal. The standard vibration periodicity, based on 50 cycle current, is 3,000 cycles per second, but this figure can be varied by means of different motor windings. As the actual source of vibration is an out-of-balance weight, variation of amplitude is also possible within reasonable limits.

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SANDALE TELEVISION STATION

A temporary television transmitting station at Sandale, Cumberland, some 14 miles south west of Carlisle, was opened by the British Broadcasting Corporation on November 5. This station, which will enable transmissions in this area to be begun many months earlier than would otherwise have been possible, will operate on Channel 4, horizontal polarisation being used.

The transmitting site is about 1,200 ft. above sea level and the aerial is mounted on a temporary 100 ft. mast. As there are at present no cable circuits the sound signals will be picked up by radio from the television stations at Pontop Pike or Holme Moss and the vision signal from Pontop Pike through a Post Office receiving station at Haltwhistle, where it will be re-transmitted to Sandale by a micro-wave link.

STUDENTS ABROAD NEXT YEAR

OVERSEAS VACATION WORK FOR UNDERGRADUATES

During the long vacation of 1957, about 800 students from the engineering and other departments of United Kingdom universities will be going abroad for periods of 8 to 12 weeks to obtain works experience and to supplement the training received during term at their colleges. A similar number of foreign students will come here and be placed in British industry. Altogether, something over 6,000 students from more than 20 countries will join in exchange systems and benefit from living and working for periods of up to 3 months among people of a nationality other than their own.

The principal organisation sponsoring the education of students by international travel is I.A.E.S.T.E.* (the International Association for the Exchange of Students for Technical Experience) and it is reported that an official of a university in Great Britain recently wrote that he was in no doubt that I.A.E.S.T.E. is one of the best things to have happened to the universities since the war. From a purely technical point of view, a student may be able to obtain sufficient practical experience to suit his needs in his own country, but overseas experience gained during the penultimate year of his university course, with the added advantage of becoming acquainted with practices and techniques that are new to him, and living as well as working with the people of other nations, is a very excellent counterbalance to any difference there may be between practical experience obtained at home and that obtained abroad. Moreover, such an opportunity of combining work with travel may well occur only once in a lifetime and cannot, in any sense, be compared with the experience to be obtained by travelling abroad as an ordinary tourist.

The Association was founded in 1948 at a conference called in London on the initiative of the Vacation Work Committee of the Imperial College of Science and Technology, and 10 European countries sent representatives. From its very beginning the Association has followed a policy of complete independence. It is not affiliated to any other organisation. It is absolutely non-political. An examination of the list of member countries—which includes, as well as Great Britain, the United States of America, India, Israel and most European countries—will reveal that there are among them many with diverse political points of view. It is the aim of each national committee to find the best type of training abroad for the students with whom it is concerned. This is achieved by each national committee obtaining offers of training facilities from industry within its own country, together with as much information as possible relating to the positions open to overseas students. The offers are then documented and exchanged, as far as possible, for an equal number of places in other member countries; and the offers so received are distributed to the participating universities and colleges. An effort is made by the universities or colleges to nominate a suitable student for each place available and if the nomination is accepted by the firm concerned—as it usually is—arrangements are made by the national committee of the Association for the necessary labour permits, etc. The students initially meet their own travelling expenses, but the receiving industries pay them sufficient to cover the cost of living during the period of training, and, generally, something over which will help to cover the overall cost of the venture.

In 1956 there were 22 member countries† of I.A.E.S.T.E., and of these, the sponsoring body in ten cases consisted primarily of academic authorities; in five of student bodies; in four of industrial groups; and in three of government offices. All the admitted countries are required by statute, however, to set up central committees representing the academic, industrial and students spheres of interests, and each country is responsible for its own economy.

In the second year of the Association's activities—1949—13 universities and colleges in Great Britain became affiliated to I.A.E.S.T.E. (G.B.) and, by 1956, 34 were sending students abroad through the Association. Internationally, in 1948, only 413 industrial organisations were receiving students through the Association but, by 1956, nearly 2,500 industries took part; the corresponding figures for Great Britain were: 1948, 92 companies or industrial groups, and by 1956, 325 companies or groups.

GENEROUS INDUSTRIAL SUPPORT

The degree of international co-operation which has been achieved in the academic sphere has been fully matched by the co-operation of the industrial concerns of the different countries. Their participation in the exchange has been both generous and enlightened; while standing to gain comparatively little material benefit, they have provided visiting students with splendid opportunities for broadening their experience, both as engineers and as citizens.

The establishment of I.A.E.S.T.E. has also furnished international industry with a form of control of foreign students which it approves for two reasons. Firstly, the acceptance of students from overseas, through the Association, ensures that they are sponsored and recommended by the universities or colleges at which they are studying; and, secondly, industry appreciates that, by accepting overseas students through the Association, it automatically provides opportunities for undergraduate students from the universities and colleges in its own country to go abroad for similar industrial experience. Indeed, many industries now recognise I.A.E.S.T.E. as the only channel through which they are prepared to consider the reception of students from overseas for practical experience.

At a recent meeting of industrial representatives, the delegate of a large company which has accepted overseas students under I.A.E.S.T.E. for several years said: "It has become an established practice in the engineering faculties of universities in this country to encourage engineering students to spend two months of their long vacation in industry, in order to obtain practical experience in the application of the theoretical knowledge that they have gained at their universities. While this system has many advantages to commend it, it has, at the same time, a disadvantage in that the majority of the student's vacation is spent in works in this country and his general education lacks the broadening influence that is to be obtained by travelling in a foreign land. As my company engages something like 150 graduates each year, we are naturally very interested that these graduates should receive the best education possible and we, therefore, co-operate by allowing foreign students into our works, so that our own British university students can be placed in works overseas."

An industry which receives a student from abroad under the aegis of the Association makes a brief report upon him at the end of his visit, and each student also submits in duplicate, a report upon his training period in industry. The student's report is examined and assessed by the representative committee of the country which sent the student abroad, and one copy is then sent to the committee in the country visited. The other copy, together with a copy of the report which was made on the student by the company, is sent to the student's university. Analysis of the students' reports over the last seven years has shown almost complete satisfaction with the arrangements made by the Association and the receiving industries on their behalf.

ALL-ROUND ADVANTAGES

Besides the training value to the students themselves, certain other effects of the exchanges are worthy of note. One is the stimulating effect of the presence of a student from a foreign country in the workshops and offices in which he is placed. Furthermore, slight though it may be, visits of students from abroad may ultimately result in new markets for the products of the firm that receives them. Conversely, the knowledge acquired and the contacts established in the course of a study period abroad may serve the commercial interests of the firms who employ the students after their return home. Though influence of this kind can only be on a relatively small scale, it should not be overlooked that some, at least, of the young men concerned will eventually go into responsible posts in industry when it could become of importance. With the extension of the work of this Association to the under-developed countries, this factor will possibly turn out to be not inconsiderable. And finally, the student will have mixed with people having standards of values—economic, cultural or moral—different from his own and yet with whom he has lived and worked amicably. He will have increased his ability to view, and to group into recognisable patterns, the components of a modern industrial concern; he will also have had the opportunity of widening his understanding of human problems, so vital to the solution of the problem of labour relations in industry, the neglect of which can vitiate any technical advances. What better training could he have for gaining that state of receptivity to new ideas without which there can be no real progress?

* The secretary is Mr. J. Newby, and the address of the Association is Imperial College, South Kensington, London, S.W.7.

† Austria, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Iceland, India, Israel, Italy, Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Turkey, United States of America and Yugoslavia.

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CABLE MAKER'S JUBILEE

On October 26 W. T. Henley's Telegraph Works Company, Limited, celebrated the jubilee of their works at Gravesend, which were opened in July, 1906, for making impregnated-paper covered cables.

The original works covered a floor area of 177,000 sq. ft. and were designed for continuous-flow production. In 1920 the copper wire-drawing plant and annealing furnaces were extended and this part of the factory has since been further enlarged, so that wire drawn at Gravesend is also sufficient for the company's other works at North Woolwich and Birtley. Almost from the very beginning there has also been a factory for the manufacture of fuses, joint boxes and terminal boxes, and this has also been largely extended. As early as 1919 the nucleus of a research department was established and four years later a new building containing high-tension, physical and chemical laboratories was erected. At a later date a short-circuit testing plant was added.

Since the Gravesend works were opened the art of cable making has, of course, made great advances. Designs had up to then been based more or less on rule-of-thumb methods with the result that the insulation, lead and armouring were over-generously proportioned. Ionisation as a cause of cable failure had not been encountered and 11 kV was about the highest voltage in use. Soon, however, it was found necessary to double this voltage and later to raise it to 33 kV, a step forward which was made without increasing the thickness of the insulation. From then onwards developments have been rapid and the result has been the production of 132 kV cables at Gravesend with insulation thickness as small as 0·4 in.

Although the Gravesend works has now celebrated its jubilee it is fitting to recall that Henley's was founded as long ago as 1837 and that the manufacture of electric wires and cables mainly for submarine telegraph work was begun about 20 years later.

THE HUMAN ELEMENT

Communist defeat at A.E.U. ballot—Prospects for the professional engineer in U.S.A.—Feminising industry—Transforming displaced operatives into automation technicians—The cost to the employer of changing jobs—Shift-working and new wage structure for the cotton industry.

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Surprise Ballot at the A.E.U.

No result was obtained in the recent ballot for the general secretaryship of the Amalgamated Engineering Union. It is clear how the wind is blowing, however, and it is doing so from a rather unexpected quarter. The two most likely candidates were Mr. J. Scott of the London area and Mr. J. M. Boyd from Scotland. It was thought that Mr. Scott might win the first ballot but go out on the second round against a combined anti-communist vote. In the event, this has not happened. Mr. Boyd topped the first poll, followed by Mr. C. W. Hallett, the assistant general secretary. Mr. Scott was third. The communist candidate thus faded early.

This result came therefore as something of a surprise and it cannot be explained by the size of the poll. This was slightly higher than in other recent elections, but at 9·7 per cent. of the membership it is far from satisfactory. A man such as Mr. Boyd has, of course, certain advantages in the eyes of some A.E.U. members. Being a Scot he would get a good following against a Londoner over the Border, and probably in the traditional engineering areas in the north of England. By personal conviction he is also firmly in the non-conformist (and therefore radical) tradition of the trade-union movement. It has been said of one prominent communist trade-union leader that if you scratch him you find a Welsh nonconformist. In the eyes of many trade unionists, if you don't have to scratch so much the better.

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Engineering as a Career

A book published by McGraw-Hill, *Engineering as a Career*, by Dr. Ralph J. Smith, of San Jose College, sets out the scope of, and the necessary training for, an engineering career. The material is drawn from the United States where, of course, conditions are different to some extent from those in the United Kingdom, but there is a good deal of general information in the book of interest to engineers in this country, not least because the differing conditions invite comparisons in the reader's mind.

Of particular interest is the section on the profession as a whole. Writing of remuneration and prospects, Dr. Smith says that in the United States, engineering salaries compare favourably with other sciences. Starting salaries are high, and income increases with experience. On the whole, engineers with doctorates earn substantially more than those with only bachelor's degrees. Those with master's degrees do no better than those with bachelor's degrees—but this may be an oddity of the sample. Engineers in management, research, consulting and sales earn more than those in private industry while those in public service fare worst. It would be interesting to know how different a picture would be seen in this country at the top of the income scale as a result of the tax system. The tables and charts in the book suggest that the most successful engineer in the United States is a highly qualified man in contracting work or in private practice. The author, however, is fully aware that many able men with no academic qualification at all are at the top of the profession.

A book of this kind suggests the advantage which would be gained for the engineering profession in this country if similar information were available for young men about to embark on a career in engineering.

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Married Women at Work

Addressing the annual general meeting of the National Federation of Business and Professional Women's Clubs recently, the Minister of Labour spoke of the growing importance of women in jobs, including professional occupations. That women, especially married women, have come much more into the labour market in recent years is well known. Its causes are also generally appreciated—such as the rise in the cost of living, younger marriages, the growth of labour-saving equipment in the home and wartime habits of women working. It is apparent that married women at work are now established practice and are likely to become increasingly common. There is every incentive for trade and industry to accept the fact and adjust itself to some degree accordingly.

The fact that the population is growing older while industrial output is expanding means that all sources of labour will have to be tapped. Opportunities for women to work, even after they have raised families, are likely to be on the increase. This applies not only to work in factories and routine office jobs. The professions themselves are likely to feel the pressure of a lack of trainees. The current lack of engineers, for instance, is a long-term matter and it may have to be solved in part by training women in engineering and making an attractive career available to intelligent women even after they are married. The idea may be less than welcome to many professional men but the trend is all that way. This being so, there will have to be a change in the attitude of many concerns towards trained female staff. They will cease to be merely a short-term nuisance to be endured until something better turns up. Their point of view will have to be listened to and certain concessions made by the upholders of masculine omniscience. To have and to hold is going to take on a new and highly unromantic meaning in the 1960's in professional offices.

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Retraining Older Men

The suggestion that there is in the ranks of the unskilled and the semi-skilled a vast reservoir of talent was made last week by Professor M. P. Fogarty, Professor of Industrial Relations at the University of South Wales and Monmouthshire. Speaking at a conference on the human problems of automation held in Leicester, Professor Fogarty pointed out that in the early 1930's—when men now between the ages of 30 and 40 were at school—only two out of five children had a chance to continue their education. The other three got jobs in fairly low grades and some of them should be sufficiently gifted to develop into technicians.

This is yet another argument for setting up re-training facilities, a process now far advanced in the United States. Professor Fogarty argued that to do otherwise, and so waste the operatives displaced by automation, would be unfair to men who had fewer chances and little financial support to go to technical colleges and universities. He pointed out that this was a good opportunity to make up the lee-way on the United States and Soviet Russia, who had a much higher proportion of technicians to technologists than we have or are likely to have if we rely entirely on youth. Another speaker, Mr. Frank G. Woollard—a pioneer in the introduction of automation—suggested that workers could acquire the necessary knowledge by attending classes which could be taken by retired technicians who would know what was required, and also what the particular company required.

Who shall bear the cost of re-training has yet to be decided. As automation spreads—and it shows signs of spreading far more quickly than was expected even a year ago—the problems of the displaced operative and the missing technicians will require to be solved quickly. So far it seems that the company concerned should bear the cost of compensation and re-training as well as that of the new machines. Although this is in line with current American thinking—on both sides of industry—it may prove a heavy burden for the average company to bear. A solution might be found in co-operation action locally, with Government backing.

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The Cost of Labour Turnover

The rate at which wage-earners are changing their jobs is currently costing manufacturing industry £230 million a year. The cost to companies of replacing an employee ranges from £5 to £396 and adds from 5*d.* per week to £3 per week to the wage cost of each individual. These figures were given in a paper presented to the British Institute of Management national conference at Harrogate last week by Mr. R. L. Webster, chief personnel officer of Hoover Limited. They are based on a pilot survey of the cost of labour turnover, carried out among 16 firms under the guidance of a steering committee representing the Institute of Cost and Works Accountants, the Institute of Personnel Management and the British Institute of Management.

Mr. Webster pointed out that "only the best firms co-operate in a study of this nature," yet "in this series of 16 studies seven firms were adding 10*s.* or more per week to the wage cost per individual as a result of labour turnover." The cost of advertising for manual workers ranged as high as £6 3*s.* 6*d.* per engagement; the cost of ineffective learning time and scrap was not generally available but in one firm making vehicle engines the excess scrap cost for three months was £11 17*s.* per learner and at another making aluminium foil it was as high as £151 for three months. One firm with 400 employees was spending nearly £20,000 a year in extra wages on overtime and claimed that 90 per cent. of it was due to labour turnover. Mr. Webster considered that to generalise from the findings of the survey probably underestimated the real extent of the problem. The facts suggest that labour turnover in manufacturing industry is over 40 per cent. per annum of all employees, 35 per cent. for men and 54 per cent. for women. His comment, that "even if we assume that half the turnover is inevitable, the cost to the nation in economic and social terms is staggering," is fair enough.

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New Agreement in Cotton Industry

An agreement affecting more than 50,000 workers in the cotton-spinning industry has been reached after a year's negotiations covering working conditions, wage structures and the working of multiple shifts. This is the first time the principle of shift working has been accepted by the unions, and considerable improvements in productivity are expected. It will be some time, however, before the adoption of two shifts can become general since the industry relies extensively on married women for its labour. Sir Alfred Roberts, general secretary of the National Association of Card, Blowing and Ring Room Operatives, emphasised that many obstacles, most of them deeply rooted in the social habits of Lancashire, will take time to overcome.

The industry's difficulties in competing with those countries where labour costs are much lower, particularly Japan and India, have been a powerful incentive in the search for improved methods of working. The new wage structure now agreed is based on work study principles and should enable the industry to compete more effectively in world markets. Sir Alfred Roberts and Mr. C. Henniker Heaton, director of the Federation of Master Cotton Spinners Association, the joint signatories to the announcement, said that the new charter had been approved at separate meetings of the two organisations and that details will be embodied in formal documents as soon as possible.